PROCEEDINGS

OF THE

California Academy of Sciences

FOURTH SERIES

Vol. XXVIII

SAN FRANCISCO
PUBLISHED BY THE ACADEMY
1953–1956

COMMITTEE ON PUBLICATION

CONTENTS OF VOLUME XXVIII

53156

PROCEEDINGS

OF THE

CALIFORNIA ACADEMY OF SCIENCES

Fourth Series

Vol. XXVIII, No. 1 July 15, 1953

OBSERVATIONS ON *HIPPONIX ANTIQUATUS* (Linnaeus)*

BY

C. M. YONGE
University of Glasgow

Introduction

One of the most interesting of the commoner gastropods found on the shores of California is the small *Hipponix antiquatus.* It is a member of one of the many groups of limpets which have independently been evolved, but it is of particular interest owing to its sedentary habits. While it must move about in early life, at some stage, at present unknown, *H. antiquatus* settles permanently. It then proceeds to lay down calcareous matter on the surface of the underlying rock. This cemented "ventral valve" may eventually attain much the same size and thickness as the true shell. *Hipponix* may be described as a univalve which converts itself into a bivalve, but it should be noted that the valves are dorsal and ventral, resembling those of a brachiopod, not those of a lamellibranch.

Despite their interesting habits little seems to have been written about these animals. The only paper found which deals with habits is one on *H. australis.* This species lives usually on the shells of species of *Turbo* and was studied at New Caledonia by Risbec (1935). The opportunity was taken while visiting professor in the University of California in 1949 to examine, first at Berkeley and later at Pacific Grove, living specimens

---

*Being "Studies on Pacific Coast Mollusks, VII" (nos. I-VI, published in University of California Publications in Zoology, vol. 55, pp. 395-454).

of *H. antiquatus* which were obtained from Moss Beach, a little south of San Francisco, and from the shores of the Monterey Peninsula. In view of previous work on feeding in the allied *Capulus ungaricus* (Yonge, 1938) and on the pallial organs in other limpets (Yonge, 1947), special attention was paid to the mode of feeding and to the nature and mode of functioning of the organs in the mantle cavity. Some specimens were fixed in Bouin's fluid and were later sectioned, or mounted entire, in the Department of Zoology, University of Glasgow. But this paper deals primarily with observations on the living animal and no attempt has been made to give a detailed description of structure.

This work was made possible by the kind cooperation of colleagues in the Department of Zoology, University of California, Berkeley, and of Dr. R. L. Bolin and members of the staff of the Hopkins Marine Station, Pacific Grove. At Glasgow, Dr. H. F. Steedman gave great help by preparing whole mounts and cutting sections.

APPEARANCE AND HABITS

Hipponix antiquatus is the commonest of several species of its genus recorded from the coast of California (Keep and Bailey, 1935; Smith and Gordon, 1948). It ranges from south of the equator to about 42° N. latitude (Keen, 1937). It has a rounded, much flattened shell. As shown in figure **1A**, the apex is not central but lies well to the posterior side, and the outer surface is grooved. The transverse diameter of the shell is usually a little greater than the antero-posterior diameter, the specimen shown in figure 1 being 1.7 cm. by 1.6 cm. No larger specimen was found and it was also unusually regular in shape, many shells being distorted owing to the confined space in which the animal had originally settled.

The shell is smooth internally and the impression of the horseshoe-shaped shell muscle is clearly marked on the surface of both the shell and of the "ventral valve" below (fig. **1B** and **C**). The latter is formed by the epithelium of the under surface of the foot and in the same way as the shell, i.e., the pedal margins increase it in extent while it is continually being thickened by secretion from the general surface of the foot. Eventually it comes to have much the same maximum thickness as the shell, about 1 mm. It is internally concave and to about the same depth, in this case some 4 mm., as the shell (cf. fig. **1B** and **C**). The only difference between the two is that the greatest depth in the "ventral valve" is central and not posterior as it is in the shell.

Smith and Gordon (1948) state that this species occurs "In colonies under rocks at low tide; common." It was sought with greatest success in narrow, often overhung, crannies in the rock from mid-tidal levels and

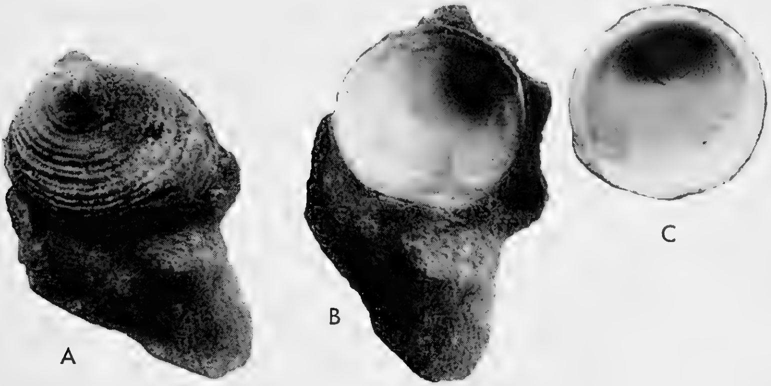


Figure 1. *Hipponix antiquatus*, photographs of shell. ×1½. **A**, shell *in situ* on rock; **B**, interior of "ventral valve" secreted by ventral surface of foot, scars of shell muscle shown; **C**, interior of "dorsal valve," i.e. true shell secreted by mantle, scars of shell muscle shown.

below. It is there protected from the full force of the Pacific surf while the movements of these waters continually bring in new supplies of organic debris and detritus of all kinds. The animals always appear to occupy rounded depressions in the rock surface. These have frequently, if not always, been made initially by rock-boring bivalves, which are extremely numerous in this rock. It is possible, however, that the depression may be further excavated during growth, presumably by means of the shell margins. But this process must cease as soon as calcareous material begins to be secreted ventrally.

Ventral Aspect

The appearance of an animal after careful removal from the rock by cutting through the attachments to the cemented ''ventral valve'' is shown in figure 2, the specimen being viewed to some extent from the anterior end so as to obtain a better view of the head and the more anterior organs in the mantle cavity. Like the majority of limpets, e.g., both the archaeogastropod Patellacea (Docoglossa) and the pulmonate *Siphonaria* (Yonge, 1947, 1952), the shell muscles (SM) unite posteriorly although in *Hipponix* the connexion is very narrow. Laterally, however, the muscles are very broad and they provide extensive attachment between the upper and lower ''valves.'' Contraction pulls the shell firmly against the ''ventral valve'' and, as this has been laid down while subject to the constraining influence of the shell, it follows that the margins of the two ''valves'' make perfect contact. This ensures protec-

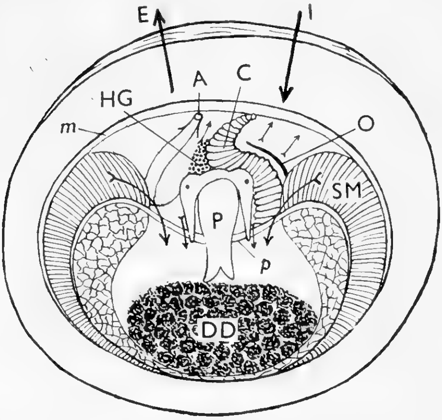


Figure 2. *Hipponix antiquatus*, appearance in life, viewed from antero-ventral aspect. ×5. *A*, anus; *C*, ctenidium; *DD*, digestive diverticula; *E*, exhalant current; *HG*, hypobranchial gland; *I*, inhalant current; *O*, osphradium; *P*, proboscis; *SM*, shell muscle; *m*, *p*, anterior margins of mantle and of foot, forming dorsal and ventral surfaces of mantle cavity. Feathered arrows indicate direction of cleansing currents.

tion against enemies and also against the force of the sea and the danger of desiccation. But it has only been achieved at the expense of mobility. The various ''homing'' limpets, e.g., species of such very widely separated genera as *Patella* and *Siphonaria*, have retained the power of locomotion and yet achieved an equal measure of protection because the margins of the shell make perfect contact with the rock surface of the ''home.''

The mantle cavity is bounded dorsally by the mantle (*m*) but ventrally by the membranous extent of the foot (*p*) which stretches forward between the shell muscles which form the lateral walls of the cavity (see also fig. 5). The head may project out of the mantle cavity, as it is shown doing in figure 2, but can be withdrawn into this by contraction of asymmetrical retractors (figs. 4 and 7; LR, RR). The head extends into a conspicuous proboscis (P) which is flanked by a pair of stout tentacles each with a small eye on the dorsal surface near to the base.

FOOT

The characteristically sessile habit of the adult of *Hipponix* is associated with major modifications of the foot. While, as in all limpets, the shell muscles are very large, the central region of the foot, which in other limpets forms the greater part of the creeping sole, is here devoid of muscle. It consists solely of a thin membrane much of which forms the floor of the mantle cavity. This is best indicated by the sections shown in figures 5 and 7. The ventral surface of the foot extends peripherally so that it covers the same area ventrally as the mantle does dorsally and its epithelium has a similar capacity for secreting shell. It is as though the animal had two mantle lobes, dorsal and ventral, but nowhere connected. Secretion of calcareous matter by the pedal epithelium may possibly represent some elaboration of the original powers of mucous production. The "ventral valve" so formed is cemented firmly to the underlying rock. As noted above, the shell muscles serve as adductors drawing the free "dorsal valve" tightly against the attached "ventral valve."

At the base of the proboscis ventrally there is a small flap of tissue which projects forward from the mesopodial tissue below. This is the propodium (figs. 4, 5 and **7A**; PR); it is terminally notched and a small gland opens on its dorsal surface. It appears to be concerned solely with attachment of the egg capsules in which connexion it will be mentioned again later.

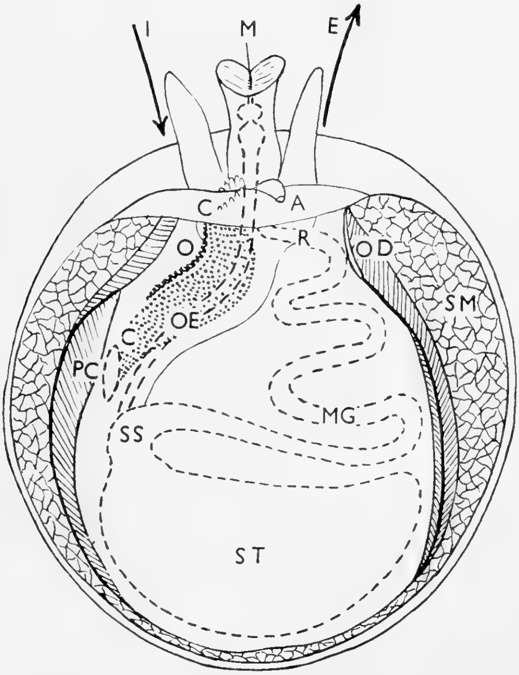


Figure 3. *Hipponix antiquatus*, dorsal view after removed from shell, based on examination of living animals and of dissections; course of alimentary canal indicated by broken lines. ×5. *C—C*, extent of ctenidium (dotted where viewed through the mantle wall); *M*, mouth; *MG*, mid-gut; *OD*, opening of oviduct; *OE*, oesophagus; *PC*, pericardium; *R*, rectum; *SS*, style-sac; *ST*, stomach. Other lettering as before.

MANTLE CAVITY

After removal from the shell, the animal may be viewed from the dorsal aspect, as shown in figure 3. Owing to the forward extension of the shell muscles and the consequent constriction of the opening of the mantle cavity, the anus (A) has been displaced dorsally, opening slightly to the right of the mid-line. The anterior end of the ctenidium (C) is similarly carried round dorsally, terminating just to the left of the anus.

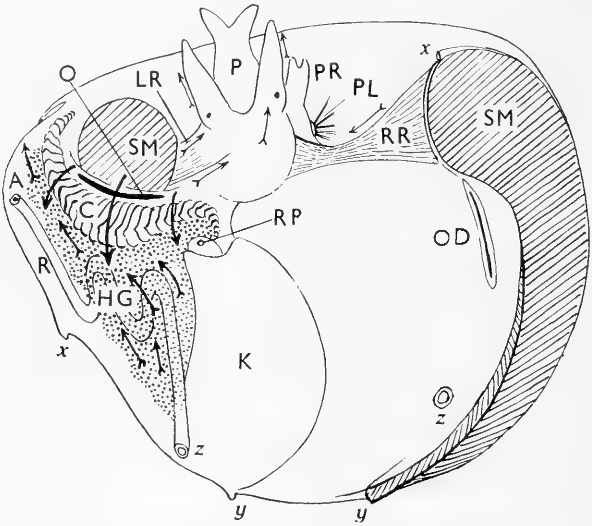


Figure 4. *Hipponix antiquatus*, dorsal view of organs in the mantle cavity after opening along the right side. ×5. *K*, kidney; *LR*, left retractor muscle of head; *PL*, plate where egg capsules (stalks only shown) are attached; *PR*, propodium; *RP*, renal pore; *RR*, right retractor muscle of head. *x—x*, cut ends of mantle edge; *y—y*, cut surfaces, posterior wall of mantle; *z—z*, cut ends of mid-gut. Other lettering as before. Plain arrows indicate respiratory current between ctenidial filaments, feathered arrows cleansing currents.

The mantle cavity can best be examined after cutting along the edge of the shell muscle on the right side and then turning the roof of the mantle cavity over to the left, giving the appearance shown in figure 4. The point of immediate interest is the asymmetry due to dorso-ventral compression in *Hipponix*. In archaeogastropod limpets, such as *Acmaea* or *Patella* (Yonge, 1947), and also in the mesogastropod *Capulus*, which is closely related to *Hipponix*, the head occupies the center of the mantle cavity. This is a consequence of secondary symmetry associated with loss of coiling in the shell and visceral mass. In all of these limpets height is seldom less than breadth, it is often greater. In *Hipponix*, on the other hand, height is always less than half the breadth. As a result of this and of the reduction of the pedal tissues (with which this compression is also associated), the mantle cavity extends relatively far back, as shown in longitudinal section in figure 5. But it also widens out internally and is very shallow. Hence the head, although it projects forward out of the middle of the opening of the mantle cavity (figs. 2 and 3), has basally been pushed over to the left (figs. 3 and 7) where the oesophagus (OE) runs into the visceral mass. This accounts for the much greater size of the right as compared with the left retractor muscle of the head (figs. 4 and 7**B**; RR, LR).

Apart from this flattening and extension posteriorly, the mantle cavity is that of a typical pectinibranch prosobranch, having the same general disposition of the pallial organs as, for instance, in *Buccinum* (Yonge, 1938). The pericardium, as revealed by dissection and in sections, is situated far to the left at the base of the ctenidium (figs. 3 and 7**C**; PC). The large kidney (fig. 4, K) covers much of the posterior wall of the mantle cavity, the renal pore (RP) opening to the left of the mid-line. Internally it is unusually capacious, as shown in figure 5. It communicates with the pericardium by way of a long reno-pericardial canal (figs. 5 and 7**C**; RC). On the right side of the cavity extends the elongated genital aperture which, in all the specimens that were dissected, was oviducal (figs. 3 and 4 OD). The rectum (R) meanders along the right side of the roof of the cavity to open, near the margin of this, at the anus (A). The large pectinibranch ctenidium (C) occupies the left side of the mantle cavity twisting over to the dorsal surface anteriorly as mentioned above. Parallel to its axis on the left and so facing the inhalant current (fig. 3, I) extends the linear osphradium (figs. 3; 4;

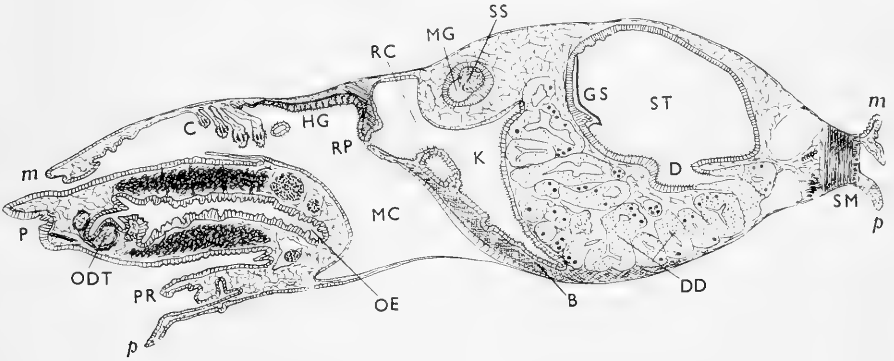


Figure 5. *Hipponix antiquatus*, longitudinal section. ×11. *B*, blood sinus; *D*, duct into digestive diverticula; *GS*, gastric shield; *K*, internal cavity of kidney; *MC*, mantle cavity; *ODT*, odontophore cartilage; *RC*, reno-pericardial canal; *SS*, style-sac with contained style. Other lettering as before.

and 7**A**, O). Between the ctenidium and the rectum, the roof of the cavity is covered by the extensive tissues of the hypobranchial gland (figs. 4; 5; and 7, HG).

CILIARY CURRENTS

The lateral cilia on the ctenidial filaments create an inhalant current (I) which enters the cavity on the left side, impinging first on the osphradium. The exhalant current, as always, leaves the cavity on the right. The ctenidium is concerned solely with creating this current and with respiratory exchange. As shown in figure 4, the filaments are broad, like those of a typical pectinibranch. Where the filaments are modified in connexion with ciliary feeding, they are invariably elongated, e.g. in *Vermetus novae-hollandiae, Capulus ungaricus* and, to a striking extent, *Crepidula fornicata* (Orton, 1912, Yonge, 1938). This elongation increases both lateral and frontal surfaces and so the extent of the lateral cilia, which create a greater inhalant current, and of the frontal cilia which are here concerned with food collection. In *Hipponix* there is only a moderate inhalant current, adequate for the limited respiratory needs of the animal, while the frontal cilia retain their primitive function of cleansing.

In ciliary feeding species, moreover, collected particles are conveyed to the mouth along the tips of the elongated filaments, and by way of special food grooves, to the mouth. This has been described in various of the Vermetidae (Yonge, 1932, 1938; Morton 1951*b*), in *Turritella communis* (Graham, 1938), in the Struthiolariidae (Morton, 1951*a*)—although *not* in the related *Aporrhais* which has the same habit of burrowing in mud (Yonge, 1937)—in *Crepidula* and other members of the Calyptraeidae (Orton, 1912, Yonge, 1938), in *Capulus ungaricus* (Yonge, 1938), and in the freshwater *Viviparus viviparus* (Cook, 1949).

Careful observation in *Hipponix* showed that there is no passage of particles along the tips of the filaments or within a food groove to the mouth. The circulation of water and the disposal of waste particles in the mantle cavity is essentially as in typical pectinibranchs. As described elsewhere (Yonge, 1938), there are three currents concerned with rejection of sediment, (*A*) those carrying heavier particles to the *inhalant* opening; (*B*) those carrying medium particles across the *floor* of the mantle cavity; (*C*) those carrying the finest particles over and between the ctenidial filaments for later consolidation *dorsally* in the mucus from the hypobranchial gland. Material in currents *B* and *C* is passed out through the exhalant aperture. The feeding currents in ciliary feeding Prosobranchia represent modifications of some or all of these currents (Yonge, 1938).

In *Hipponix* the only modification is due to the constriction of the opening of the mantle cavity which has had the effect of carrying the greater part of the ctenidium on to the dorsal surface so that, as shown in figures 2 and 7, the filaments hang down above the head. The inhalant current (I) created by the lateral cilia enters on the left side, passes through the ctenidium and leaves as an exhalant current (E) on the right (fig. 3). The heaviest particles drop out of suspension on the left and are removed by cilia of current *A* on the floor of the inhalant aperture (fig. 2). The current then impinges on the osphradium (O) and passes between the filaments. Larger particles are carried to the tip of the filaments by the frontal cilia and are rejected by cilia on the surface of the head, on the sides of the tentacles and on the floor of the mantle cavity to the right, that is current *B* (fig. 4). The finest particles are carried between the filaments and are then consolidated in the mucus from the hypobranchial gland. Cilia of current *C* then carry the mucus-laden masses to the exterior. The large size of the hypobranchial gland indicates the amount of material carried normally in suspension. Observations in life revealed great quantities of mucus in the mantle cavity. Posterior to the line of the right retractor of the head, the floor of the mantle cavity is not ciliated. No doubt any material which may accumulate here is forced out when the shell muscles contract.

It was initially most surprising to find no trace of ciliary feeding in this sedentary animal. The Vermetidae, which are also cemented, feed either by ciliary currents or by mucus strings (Yonge, 1932, 1938; Yonge and Iles, 1939; Morton, 1951*b*) while *Capulus ungaricus,* which is closely related to *Hipponix* and still potentially, if seldom actually, mobile is a ciliary feeder (Yonge, 1938). In that species particles collected by the ctenidia are carried in a ciliary tract to the upper surface of the propodium (much larger than that of *Hipponix*) where the proboscis collects the mucus-laden masses by means of the radula. Orton (1949) has pointed out that *Capulus* may also live on the shells of lamellibranchs, such as *Modiolus* and *Monia,* and probably takes some of the food of these animals by inserting the proboscis into the mantle cavity. But in *Hipponix* there is no doubt that ctenidium and ciliary rejection currents are in no way modified for feeding.

The presence of a large osphradium is interesting. If this organ be solely chemo-receptive then its persistence in a sedentary animal is surprising. On the other hand if, as suggested elsewhere (Yonge, 1947), it is, at least primarily, a tactile organ concerned with estimating the amount of sediment carried in with the inhalant current, then its retention would be expected. A sedentary animal is particularly susceptible to danger from accumulation of sediment within the mantle cavity.

Alimentary Canal

The mouth consists of a vertical slit at the end of the proboscis and at the base of the two lateral flaps in which this terminates. There is a small, and certainly functional, radula and small salivary glands. The buccal cavity leads into what is termed by Graham (1939) the anterior oesophagus and which possesses in *Hipponix* a dorsal ciliated food-channel of unusual width. As in other style-bearing mesogastropods, such as *Capulus* and members of the Calyptraeidae, the lateral glandular pouches primitively associated with the mid-oesophagus (Graham, 1939) are absent in *Hipponix*. As already noted, the oesophagus passes to the left to enter the visceral mass; there it enters the exceptionally large stomach (ST) which, as shown in figures 3 and 5, occupies the greater part of the posterior region of the visceral mass.

The general appearance of this organ when opened mid-dorsally is shown in figure 6. The oesophagus (OE) enters ventrally on the left side; the mid-gut (MG) which is separated by a conspicuous typhlosole (TY) from an associated style-sac (SS), leaves on the same side but dorsally (fig. 3). There is a common opening, on the floor of the stomach, for all the ducts of the digestive diverticula (figs. 5 and 6; D). This opening lies near to the gastric shield (GS) against which the short style bears. All of these structures lie on the left side of the stomach together with the usual sorting mechanisms of ridges and grooves, all richly ciliated. But some three quarters of the stomach consists of a capacious caecum which

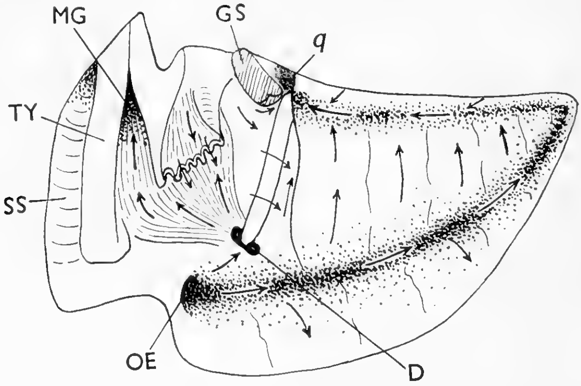


Figure 6. *Hipponix antiquatus*, stomach opened along dorsal surface, showing appearance in life. ×10. *D*, opening of duct into digestive diverticula (ventral); *MG*, opening into mid-gut (dorsal) separated by typhlosole (*TY*) from style-sac (*SS*); *OE*, opening of oesophagus (ventral). *q*, *q*, material accumulated by ciliary currents at side of gastric shield (*GS*) where normally caught up by the substance of the revolving head of the style.

extends to the right. The walls of this appear corrugated when the stomach is opened, ciliation is poorly developed but there is evidence of muscular contraction, sections revealing the presence of some strands of muscle around this region of the stomach.

The digestive diverticula form a compact mass on the ventral side of the stomach as shown in figures 2 and 5 (DD). The tubules contain many dark spherules (seen in the section shown in fig. 5) which are probably of an excretory nature. Owing to their presence the diverticula form a black mass when viewed from the ventral side (fig. 2). Among the tubules and around the gut generally there is abundance of a yellow, vescicular connective tissue. The mid-gut and rectum extend forward in the roof of the mantle cavity where they form a series of loops (fig. 3, MG and R). In an animal with a shell diameter of 12 mm. these terminal regions of the gut pulled out to a length of some 22 mm.

FOOD AND FEEDING

The only previous account of feeding in *Hipponix* appears to be that of Risbec (1935) on *H. australis.* This species lives on the shells of other gastropods, usually of species of *Turbo,* and characteristically near to the exhalant aperture. So situated, it feeds on the faecal pellets of the "host," the terminal processes of the proboscis separating and then coming together rapidly when the relatively enormous food masses are swallowed. *Hipponix antiquatus* feeds in essentially the same manner but on fragments of material—organic detritus, pieces of algae, etc.—that are carried within the very limited area in front of the shell where alone the proboscis can browse. In the absence of automatic supplies of food, such as those received by *H. australis* from the animal it lives upon, this type of feeding can only be carried on by a sedentary animal if food supplies are constantly being renewed by water movements.

The proboscis itself is muscular and very active. The terminal lobes, with the mouth which they flank, were frequently seen to open widely and grope forward in apparent search for food. The odontophore was then seen to protrude from the mouth opening. Somewhat similar observations were made on *C. ungaricus* after mucus-laden food masses had been carried on to the surface of the propodium (Yonge, 1938). In this species, however, the proboscis, which is grooved anteriorly, represents the much extended terminal lobes in *Hipponix.* How widely the mouth must dilate in *H. antiquatus* is indicated by the nature of the stomach contents. These, together with much amorphous matter, probably organic detritus, comprise sand grains and also fragments of calcareous coralline algae up to 2 mm. long and 0.5 mm. wide. The radula must convey these fragments into the buccal mass and anterior oesophagus the powerful ciliation of which, possibly aided by some muscular action, serving to carry them into the stomach.

Within the stomach material would appear initially to pass to the right, into the caecal extension, as indicated in figure 6. This serves as a store and perhaps to some extent also as a gizzard although the triturition which must occur before the larger particles can pass into the mid-gut is probably completed by the action of the style and gastric shield. Certainly particles are carried to the edge of the gastric shield (fig. 6, *q*) where, in the intact stomach, they will be caught up in the head of the rotating style. Fine particles only will finally be carried into the large duct (D) leading into the digestive diverticula; the greater part of the stomach contents must pass, essentially unchanged apart from digestion of starch and some triturition, into the mid-gut. A very similar type of stomach, with a large caecal extension, is described by Graham (1939) in *Pomatias (Cyclostoma) elegans.*

Within the mid-gut the faecal material becomes firmly compacted into pellets of relatively enormous size. Each is oval in shape and from 700 to 800 μ long and about 500 μ in diameter. When crushed they are found to consist of fine amorphous material, dark green in colour with fine fragments of lime and silica. These pellets may occur in multiple rows and in such numbers as to distend the mid-gut and rectum to as much as three times the normal diameter. Indeed the roof of the mantle cavity may be largely occupied by as many as 16–20 of these pellets within the coilings of the mid-gut and rectum. The anal opening, normally small, is greatly distended at defecation. The exhalant current must aid in carrying the pellets clear of the shell where water movements may dispose of them. In the quiet water of an aquarium tank the pellets were deposited in large numbers just outside the margin of the shell. Under these conditions they might possibly be seized by the groping proboscis and swallowed.

There is no evidence of any discrimination in feeding. Anything that is available, up to a relatively very large size, appears to be swallowed. The oesophagus is wide enough to permit the passage of, and the stomach capacious enough to store, large particles. The stomach is that typical of a style-bearing gastropod, as summarized by Graham (1939), permitting (1) mixing of food with the style substance, (2) sorting of fine particles for passage into the digestive diverticula, (3) removal of larger particles and waste from the digestive diverticula into the mid-gut, (4) rotation and passage into the stomach of the style. The very great amount of indigestible matter in the food is accumulated into exceptionally large faecal pellets which cannot cause fouling of the mantle cavity.

Reproductive Organs

Every specimen examined in life or dissected was female. One small specimen of which longitudinal sections were made showed no sign of reproductive organs and was presumably immature. The related *Capulus ungaricus* is a protandrous hermaphrodite (Giese, 1915) and this must surely also be true for *Hipponix*.* In *C. ungaricus* the reproductive system is simple, consisting, in the male phase, of a testis with associated ampullae and a duct leading into a pouch with which a receptaculum communicates by a fine duct. The male genital opening lies at the side of the right shell muscle and the sperm is carried by way of a ciliated groove to the tip of a simple penis which is without glands. After sex change, the gonad enlarges to form an ovary without ampullae, the pouch of the male phase now becomes what Giese describes as a uterus into which the receptaculum continues to open. The sperm groove and the penis disappear but the female reproductive aperture, although longer, remains in the original position.

Presumably the males, being younger and probably more active, are able to move on to and copulate with the larger and probably completely immobile females. Jones (1949) describes the presence of small specimens of *C. ungaricus* on the shells of larger ones, and these may well have been males and females respectively. After copulation, sperms would presumably be stored in the receptaculum and later fertilize the eggs when they entered the "uterus." The latter is thick-walled and glandular and responsible for the formation of the protective capsule discussed in the next section.

The small specimen of *H. antiquatus* without reproductive organs was some 6 mm. in diameter and was attached to rock. If this animal was indeed immature and if all members of this species are protandric hermaphrodites then they cannot be mobile in a subsequent male phase. Certainly no small mobile individuals were observed and in the very turbulent conditions where *H. antiquatus* lives, permanent attachment in early life would seem to be almost essential. This matter cannot be regarded as settled but all available evidence, admittedly very limited, indicates that the species, almost certainly a protandric hermaphrodite, is not mobile in the male phase and so copulation cannot occur. If this be so, then fertilization may occur in one of two ways.

The first possibility is that the spermatazoa are liberated freely into the sea and that fertilization occurs after these have been carried into the mantle cavity and have entered the genital aperture of a female. Such "current fertilization" is known to occur in *Turritella communis*

---

*The parasitic *Thyca stellasteris*, according to Koehler and Vaney (1912), is not hermaphrodite although the male is smaller than the female.

(Fretter, 1946) and in various members of the Vermetidae (Morton, 1951*b*). All of these animals are, however, ciliary feeders (Graham, 1938, Morton, 1951) and so with enlarged ctenidia which create a powerful inhalant current. In addition the pallial genital duct is widely open ventrally to permit the reception of sperm carried to it in the water. All of these animals, moreover, probably live in numbers together and in comparatively still water, i.e. under conditions where a local concentration of sperm adequate to ensure fertilization could be produced. In *Hipponix* the inhalant current is much weaker, the concentration of animals is less while the water movements seem normally far too great to allow any effective concentration of sperm. Further, the very short pallial oviduct in *Hipponix* does not provide the facilities for entrance of water-borne sperm that are present in *Turritella* and the vermetids.

The other alternative is that sperm produced during the male phase are stored for subsequent fertilization of eggs produced by the *same animal* when it passes into the female phase. This would not be unprecedented in the Mollusca, having been shown to occur in the wood-boring lamellibranch, *Xylophaga dorsalis* (Purchon, 1941). This animal alternates in sex but the sperms produced in a male phase are stored in a receptaculum for use in the subsequent female phase. *Xylophaga dorsalis* lives largely isolated in drift wood and this is probably the only feasible method by which fertilization can be assured. Although the habitat is different, the problem in the case of *H. antiquatus* is not dissimilar and the solution may be the same.

The female reproductive organs are very similar to those described by Giese in *Capulus*. They are situated on the extreme right side of the visceral mass and consist of an ovary and, to employ the terms used by Fretter (1946), a gonadial duct (incorporating renal constituents), and a wide pallial region (fig. 7, OD) forming a capsule gland into which opens, by a narrow duct posteriorly (fig. 7**B**, RS), a rounded receptaculum seminis. In section sperm were seen within this organ. The eggs are large, containing great quantities of yolk, when they leave the ovary (fig. 7**C**, OV) and there is no evidence of any albumen gland. A capsule is almost certainly laid down around each egg, after fertilization by sperm from the receptaculum, by the conspicuously thick and glandular walls of the capsule gland (uterus of Giese). In this state the eggs will be passed into the mantle cavity.

ATTACHMENT OF EGG CAPSULES

Sedentary Mesogastropoda must either attach the egg capsules to the inside of the shell, as do the Vermetidae (Morton, 1951*b*), fasten them

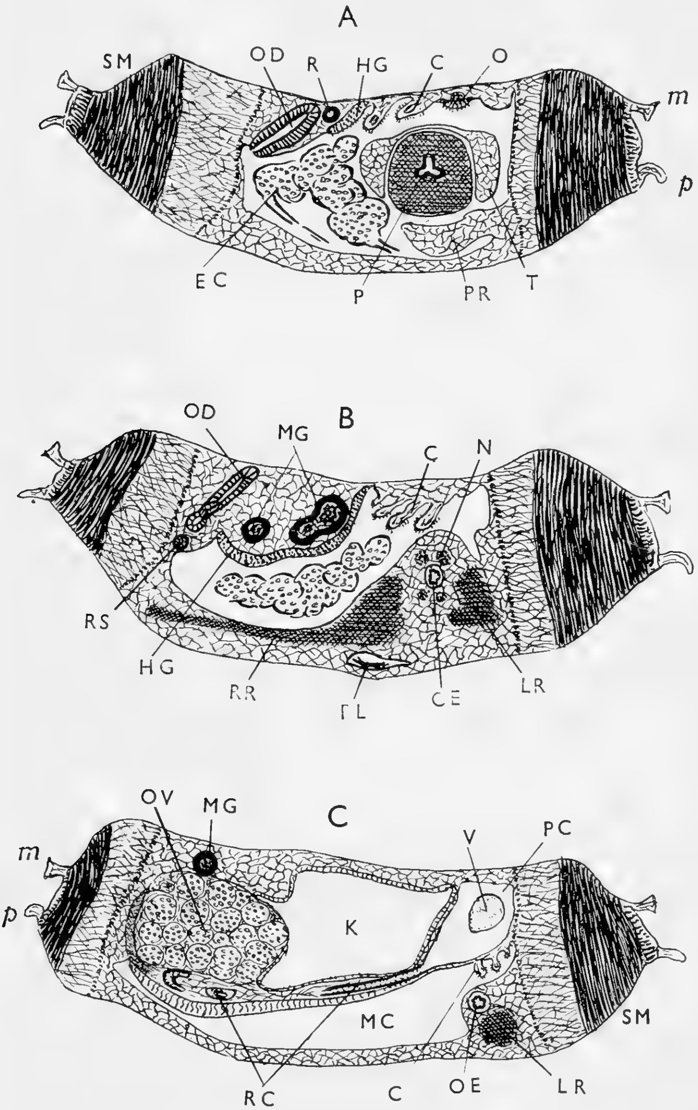


Figure 7. *Hipponix antiquatus*, transverse section through the anterior **(A)**, middle **(B)**, and posterior **(C)** regions of the mantle cavity. ×5. *EC*, egg capsules; *N*, nerve collar at base of proboscis; *OV*, ovary containing large, yolk-filled eggs; *RC*, reno-pericardial canal, showing opening into pericardium (*PC*); *RS*, duct from oviduct (capsule gland) into receptaculum seminis; *T*, tentacle; *V*, ventricle. Other lettering as before.

to the rock or pebbles on which the female rests, as in Calyptraeidae such as *Crepidula fornicata* (Lebour, 1937), or else retain them secured to the actual body of the female. This is the case in both *Capulus* and *Hipponix*. In *C. ungaricus* a single large egg capsule or cocoon is attached to the large propodium of the female. Full references to literature are given by Thorson (1946) who summarizes previous work in the statement that "Each female protects a single thin-walled cocoon of the form of a sausage, and each cocoon contains several eggs, 200 μ across, which hatch as veligers through a fissure on the under side of the cocoon."

Although Risbec (1935) does not mention males and gives a very imperfect account of the female genital system in *H. australis,* he gives a good description of the egg capsules in this species. He notes that it is impossible to observe egg-laying and the process of formation and attachment of the capsules. This is equally true for *H. antiquatus.* He describes the presence of six or more capsules each containing a number of eggs and attached by a slender stem to a plate which is itself imbedded in the tissues of the foot. He considered that these sacs received the eggs and also yellow nutritive material of a fatty nature. He was unable to observe the role of the foot in the formation and attachment of these capsules.

Conditions are essentially similar in *H. antiquatus.* After the completion of egg-laying the mantle cavity of the female is completely filled by from six to eight egg capsules each containing up to 50 yellowish eggs. The eggs measured about 350 μ in diameter, the greatest transverse diameter of the capsules being 840 μ. Each capsule was, as in *H. australis,* attached by an attenuated stalk to a perforated calcareous plate which in turn was attached within a membranous area situated in the depression ventral of the propodium (figs. 4, 7**C**, and 8; PL). As shown in figure 8, the capsules usually bulge forward so that they may project a little distance out of the mantle cavity (at least when the animals have been detached). The head is pushed over to the left of the mantle cavity and the animal must have some difficulty in maintaining the necessary circulation of water through the mantle cavity.

Unfortunately, it was impossible to observe the mode of formation and attachment of the egg capsules. Owing to the sedentary habit of this animal, full details of this process could probably only be made out by examining great numbers of animals during the period of egg-laying in hope of obtaining animals in all stages. The first egg-carrying female was obtained on April 5; during the summer all animals had egg capsules although some of these were empty.

It is, however, certain that the eggs are large and yolky when they leave the ovary, where they were observed in sections (fig. 7**C**, OV). After

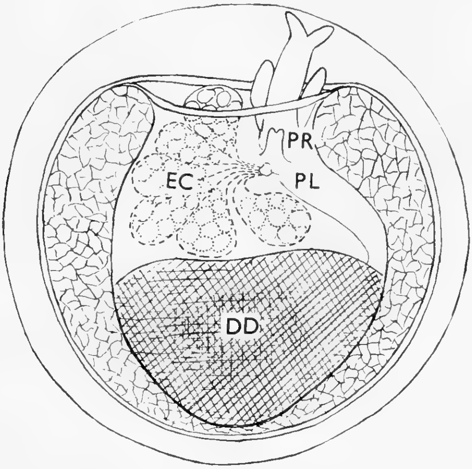


Figure 8. *Hipponix antiquatus*, ventral aspect with egg capsules in the mantle cavity. ×5. Lettering as before.

fertilization they presumably each receive a protective covering while in the capsule gland. It is, however, likely that the large capsules, each containing many eggs, are secreted by the gland that opens on the dorsal surface of the foot and which is certainly active, judging from sections, at this time. Moreover, it has been shown by Werner (1948) that, in *Crepidula fornicata*, a stalked capsule is secreted around the eggs by such a gland in the propodium. The calcareous plate and its investing membrane may be formed within the pocket ventral to the propodium; sections show evidence that the epithelium has secreted this membrane. But it is not advisable to speculate further on a matter that can only be determined by observation.

So far as could be determined, all eggs developed. There was no evidence that any of them formed food for others or that the capsules contained any additional nutritive material as suggested by Risbec. The embryos develop into fully shelled larvae but whether these actually crawl away after emergence from the capsules, as described by Risbec for *H. australis*, was not seen. In view of the very specialized habitat, it is more than probable that, in *H. antiquatus* also, the young crawl away from the parent to settle in due course permanently on the adjacent rock surface.

Discussion

Gastropods which possess the limpet form and the accompanying habit of life are particularly well fitted for survival on a hard substratum in the turbulence of the intertidal or shallow waters where such substrata normally occur. It is therefore not surprising that the limpet form, with its secondary symmetry (see Yonge, 1947, p. 490, fig. 31) has independently been evolved on a number of occasions. The particular conditions that exist in *Hipponix* are most suitably discussed by comparing them with those found in examples of the other chief types of marine limpets.

In figure 9 comparison is made between four types of limpets, (**A**) *Diodora (Fissurella)* and (**B**) *Acmaea* are both archaeogastropod limpets the former having paired, i.e. zygobranchous, aspidobranchiate ctenidia, the latter having a single aspidobranch ctenidium. (**C**) *Hipponix* is a mesogastropod limpet with a pectinibranch ctenidium and (**D**) *Siphonaria* is a pulmonate with a secondary gill in what has been a pulmonary mantle cavity. A cap-like shell and a horseshoe-shaped shell muscle (with the

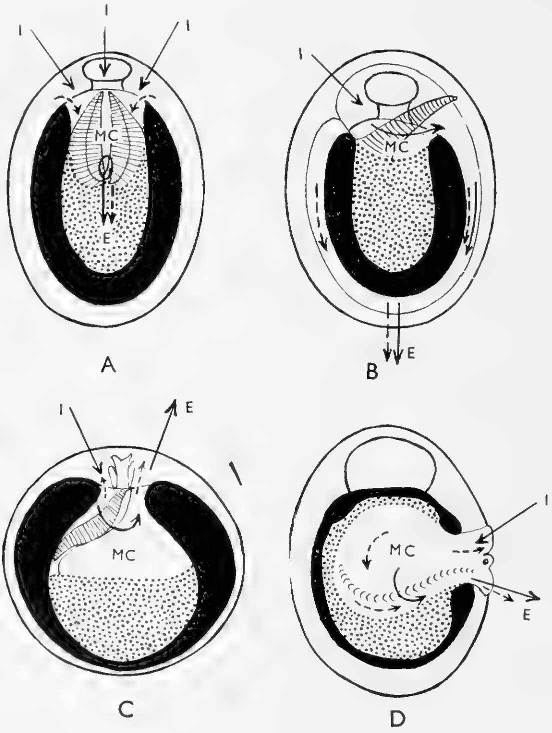


Figure 9. Diagrammatic comparison, from dorsal aspect, of four types of limpets, showing mantle cavity (*MC*) with inhalant (*I*), exhalant (*E*) and major cleansing currents (latter broken arrows), also shell muscles (black) and visceral mass (stippled). **A**, *Diodora* (Archaeogastropoda, Fissurellidae) with paired and symmetrical ctenidia, exhalant current dorsal; **B**, *Acmaea* (Archaeogastropoda, Patellacea) with single aspidobranch ctenidium, exhalant current posterior; **C**, *Hipponix* (Mesogastropoda) with pectinibranch ctenidium, exhalant current anterior; **D**, *Siphonaria* (Pulmonata) secondary gill, exhalant current on right.

opening on the right in *Siphonaria*) are common to all. The course of the respiratory and cleansing currents may be briefly summarized. The anterior mantle cavity of the prosobranchs (**A**–**C**) has a generalized anterior inhalant current (I) in **A** but, with the loss of the right ctenidium, this is confined to the left in **B** and **C**. In **A** the exhalant current (E) issues dorsally, through the shell aperture found in all zygobranchous gastropods and here apical in position, in **B** it is carried by way of the right pallial groove to the posterior end of the animal, whence also passes sediment collected in the mantle (nuchal) cavity and in the pallial grooves. From such a condition have been derived those in the more specialized *Lottia, Patina,* and *Patella* (Yonge, 1947) with their secondary pallial gills. These Patellacea (Docoglossa) represent the most successful of all limpets and this may well be associated with the use they, alone among limpets, have made of the pallial grooves. In *Hipponix* (**C**), apart from the flattening already discussed, the mantle cavity and its currents are those of a typical pectinibranch. In **D** the pulmonate mantle cavity has been successfully readapted for aquatic life by the appearance of secondary gills within this (Yonge, 1952) and *not* in the pallial grooves. The restricted opening of the mantle cavity on the right side is retained with the exhalant current issuing immediately posterior to the inhalant opening.

It is in the matter of feeding that *Hipponix,* and the mesogastropod limpets in general, differ from these archaeogastropod and pulmonate limpets. The latter all browse on encrusting vegetation, moving very slowly over the rock and scraping this with the broad radula. The mesogastropod limpets may be divided into (1) those in which the ctenidial filaments have been greatly elongated and which feed exclusively by ciliary currents, i.e. *Crepidula* and *Calyptraea* (Calyptraeidae) and (2) those in which there is a pronounced proboscis. In both groups the power of movement is lost, effectively even where the animal does not actually become attached. In the Calytraeidae movement ceases to be necessary because food, suspended in the inhalant current, is brought to the animal. But in the second group a most interesting variety of conditions prevails.

In *Capulus,* which is the least specialized, the grooved proboscis, formed by prolongation of the terminal lobes in *Hipponix,* may be used to take in food collected by the enlarged ctenidia (Yonge, 1938) but it may probably be also used to take in material similarly collected by a lamellibranch (Orton, 1949). In both *Hipponix australis* and *H. antiquatus* the ctenidium is not concerned with feeding, the proboscis swallowing relatively large food masses. In the former species, which lives on a "host" animal, the habit has resemblance to that described by Orton for *C. ungaricus,* but *H. antiquatus* is not dependent on any other animal. Although cemented to the substratum, yet it uses the proboscis to collect food in front of the shell. Species of a third genus, *Thyca,* have also lost the power of movement but in association with a completely parasitic life. They are ectoparasitic on echinoderms, the foot being reduced but the long proboscis penetrating deep into the tissues of the host (Schepman and Nierstrasz, 1909; Koehler and Vaney, 1912). The disc of attachment is formed by the proboscis, the columellar muscle described by Koehler and Vaney apparently consisting of the retractor muscles of the head.

In *H. antiquatus* the three most striking characteristics are (1) the flattening of the shell, with its consequences on the form of the mantle cavity and the disposition of the head, (2) cementation to the substratum by the secretion of a ventral "valve" by the undersurface of the foot and with consequent loss of motility, and (3) feeding, while so attached, by means of the proboscis. All three, however, are related to one another and to the habitat. A much flattened limpet which was cemented to the substratum would have survival value under the conditions where *H. antiquatus* lives, namely within crevices among rocks exposed to the full and almost unvarying force of the Pacific surf. Under such conditions food will constantly be renewed so that exclusive dependence on the proboscis is possible. This is not the case in *C. ungaricus* which lives, sublittorally, in very much quieter water.

Again, members of both of these groups of limpets are protandrous hermaphrodites (certainly *Crepidula* and *Calyptraea,* also *Capulus* and almost certainly *Hipponix*) but have the typical female genital system of the mesogastropods with large and internally fertilized eggs. The egg capsules must of necessity be attached either to the underlying substratum or to the animal itself. Only the latter is possible in *Hipponix* because the animal is cemented. The precise period at which the sperm enters the receptaculum, which involves the question of whether self or cross fertilization occurs, remains to be determined, as does the precise manner in which the egg capsules are attached to the underside of the propodium.

There is finally the question of classification. Thiele (1931) places *Amalthea (=Hipponix)* in the Amaltheacea but *Capulus* and *Thyca* in the family Calyptraeidae. While there is certainly much still to be learned about these and allied genera and families, there can be no doubt that *Hipponix* is much more closely allied to *Capulus* than would appear from Thiele's classification, which cannot in this particular instance be supported. The precise position of *Thyca,* so greatly modified in form and habit and yet not a protandrous hermaphrodite, appears to need further scrutiny.

Summary

Hipponix antiquatus is a mesogastropod limpet of particular interest owing to its sedentary habits. It lives cemented to the substratum in crevices among rocks often fully exposed to the Pacific surf. It is highly adapted for life in such an extreme habitat.

The ventral surface of the foot secretes a "ventral valve" closely resembling the "dorsal valve," i.e. shell, secreted by the mantle. The margins of the two make perfect contact when the horseshoe-shaped shell muscle contracts.

The opening of the mantle cavity is constricted causing displacement dorsally of anus and ctenidium; the shell is also much flattened with consequent effects on the mantle cavity and displacement to the left of the head. In other respects the disposition of the pallial organs is that typical of mesogastropods.

The ctenidia are solely concerned with respiration. Feeding is by means of a muscular proboscis which is extruded from the mantle cavity and swallows relatively very large masses of organic detritus, such as fragments of calcareous algae.

The alimentary canal is modified for the reception and utilization of such food masses. The stomach is large but otherwise that typical of a style-bearing mesogastropod. There is a single opening into the ventrally disposed digestive diverticula. Faecel pellets are exceptionally large.

Available evidence indicates that *H. antiquatus*, like the allied *Capulus ungaricus*, is a protandric hermaphrodite. Owing to the sedentary habit and to the rough water in which it lives, cross fertilization may be impossible and it appears more probable that spermatozoa produced during the male phase are stored in the receptaculum for fertilization of eggs produced in the subsequent female phase.

Large egg capsules, each containing a number of large, yolky eggs, are attached to a calcareous plate embedded ventral to the propodium. The mantle cavity is largely filled by these capsules during spring and early summer.

In comparison with archaeogastropod and also pulmonate marine limpets, mesogastropod limpets are sedentary, feeding by means of ciliary currents (*Crepidula, Calytraea, Capulus*) or by means of a proboscis either on organic detritus or faeces (*Hipponix* spp.) or else parasitically (*Thyca*). With the exception of *Thyca*, all of these limpets are also protandric hermaphrodites.

REFERENCES

COOK, P. M.

1949. A ciliary feeding mechanism in *Viviparus viviparus* (L). *Proceedings of the Malacological Society of London*, vol. 27, pp. 265–271.

FRETTER, V.

1946. The genital ducts of *Theodoxus*, *Lamellaria* and *Trivia*, and a discussion on their evolution in the prosobranchs. *Journal of the Marine Biological Association of the United Kingdom*, vol. 26, pp. 312–351.

GIESE, M.

1915. Der Genitalapparat von *Calyptraea sinensis* Lin., *Crepidula unguiformis* Lam. und *Capulus ungaricus* Lam. *Zeitschrift für wissenschaftliche Zoologie*, Bd. 114, pp. 169–231.

GRAHAM, A.

1938. On a ciliary process of food-collecting in the gastropod *Turritella communis* Risso. *Proceedings of the Zoological Society of London*, ser. A, vol. 108, pp. 453–463.

1939. On the structure of the alimentary canal of style-bearing prosobranchs. *Proceedings of the Zoological Society of London*, ser. B, vol. 109, pp. 75–112.

JONES, N. S.

1949. Biological note on *Capulus ungaricus*. *Marine Biological Station at Port Erin, Isle of Man. Annual Report* for 1948 (no. 61), p. 29.

KEEN, A. M.

1937. An abridged check list and bibliography of west North American marine Mollusca. Stanford University Press, California.

KEEP, J., and J. L. BAILY, JR.

1935. West coast shells. Stanford University Press, California.

KOEHLER, R., and C. VANEY

1912. Nouvelles formes de Gastéropodes ectoparasites. *Bulletin Scientifique de la France et de la Belgique*, T. 46, pp. 191–217.

LEBOUR, M. V.

1937. The eggs and larvae of the British prosobranchs with special reference to those living in the plankton. *Journal of the Marine Biological Association of the United Kingdom*, vol. 22, pp. 105–166.

MORTON, J. E.

1951*a*. The ecology and digestive system of the Struthiolariidae (Gastropoda). *Quarterly Journal of Microscopic Science*, vol. 92, pp. 1–25.

151*b*. The structure and adaptations of the New Zealand Vermetidae. Part 1: The genus *Serpulorbis*. Part 2: The genera *Stephopoma* and *Pyxipoma*. Part 3: *Novastoa lamellosa* and its affinities. *Transactions of the Royal Society of New Zealand*, vol. 79, pp. 1–51.

ORTON, J. H.

1912. The mode of feeding of *Crepidula*, with an account of the current-producing mechanism in the mantle cavity, and some remarks on the mode of feeding in gastropods and lamellibranchs. *Journal of the Marine Biological Association of the United Kingdom*, vol. 9, pp. 444–478.

1949. Note on the feeding habit of *Capulus ungaricus*. *Marine Biological Station at Port Erin, Isle of Man. Annual Report* for 1948 (no. 61), pp. 29–30.

PURCHON, R. D.

1941. On the biology and relationships of the lamellibranch *Xylophaga dorsalis* (Turton). *Journal of the Marine Biological Association of the United Kingdom*, vol. 25, pp. 1–39.

RISBEC, J.

1935. Biologie et ponte de mollusques gastéropodes Néo-Caledoniens. *Bulletin de la Societe Zoologique de France*, T. 60, pp. 387–417.

SCHEPMAN, M. M., and H. F. NIERSTRASZ.

1909. Parasitische Prosobranchier der Siboga-Expedition. Siboga-Expeditie, no. XLIX.[2]

SMITH, A. G., and M. GORDON

1948. The marine mollusks and brachiopods of Monterey Bay, California, and vicinity. *Proceedings of the California Academy of Sciences*, vol. 26, pp. 147–245.

THIELE, J.

1931. Handbuch der systematischen Weichtierkunde, Bd. 1, pp. 1–376.

THORSON, G.

1946. Reproduction and larval development of Danish marine bottom invertebrates. *Meddelelser fra Kommissionen for Danmarks Fiskeri—Og Havundersøgelser*. Serie: Plankton, Bind IV, pp. 1–523.

WERNER, B.

1948. Über den Laichvorgang der amerikanischen Pantoffelschnecke *Crepidula fornicata* L. *Verhandlungen Deutsche Zoologische Kiel*, 1948, pp. 262–270.

YONGE, C. M.

1932. Notes on feeding and digestion in *Pterocera and Vermetus*, with a discussion on the occurrence of the crystalline style in the Gastropoda. Scientific Report Great Barrier Reef Expedition (1928–29), British Museum (Natural History), vol. 1, pp. 259–281.

1937. The biology of *Aporrhais pes-pelecani* (L.) and *A. serresiana* (Mich.). *Journal of the Marine Biological Association of the United Kingdom*, vol. 21, pp. 687–704.

1938. Evolution of ciliary feeding in the Prosobranchia, with an account of feeding in *Capulus ungaricus*. *Journal of the Marine Biological Association of the United Kingdom*, vol. 22, pp. 453–468.

1947. The pallial organs in the aspidobranch Gastropoda and their evolution throughout the Mollusca. *Philosophical Transactions of the Royal Society of London*, ser. B., vol. 232, pp. 443–518.

1952. The mantle cavity in *Siphonaria alternata* Say. *Proceedings of the Malacological Society of London*, vol. 29, pp. 190–199.

YONGE, C. M., and E. J. ILES

1939. On the mantle cavity, pedal gland, and evolution of mucous feeding in the Vermetidae. *Annals and Magazine of Natural History* (ser. 11), vol. 3, pp. 536–556.

PROCEEDINGS

OF THE

CALIFORNIA ACADEMY OF SCIENCES

Fourth Series

Vol. XXVIII, No. 2 July 15, 1953

THE CALIFORNIA ACADEMY—LINGNAN DAWN-REDWOOD EXPEDITION

BY
J. LINSLEY GRESSITT
Research Associate
California Academy of Sciences

The discovery in West Central China in 1945–46 (see Chaney, 1948) of a living species of the ancient, fossil, coniferous genus *Metasequoia,* a possible ancestor of the redwoods, aroused widespread interest in the tree. After Dr. R. W. Chaney, of the University of California, made a hurried trip to see the trees in the early spring of 1948 an arrangement was made between the California Academy of Sciences and Lingnan University for a joint expedition to spend considerable time in the area in the summer of 1948. The travel expenses were supplied by the California Academy of Sciences and personnel and equipment by Lingnan University.

The trees were known from a few localities along the border of Szechuan and Hupeh provinces, thirty to seventy-five miles south of Wan Hsien on the Yangtze River below Chungking. In the early reports just over 100 trees were mentioned, though it was estimated there were many more. We were able actually to count 1219 trees, though not all the young trees, and no doubt not quite all the large trees, are included in our count. We searched the country in several directions for added stands. If more exist, they are probably in a few limited pockets not far to the west, east of Chungking.

Metasequoia glyptostroboides Hu and Cheng, 1948 (fig. 1), is a large and impressive conifer. It grows to a height of 115 feet and a diameter of 8 feet. Actually there is only one tree this large, though there are several about 100 feet high and 5 feet in diameter (at 6 feet above the

Figure 1. One of the largest *Metasequoia* trees, located in lower Suisapa Valley near Hsiao-ho.

ground). The trees are straight, and not irregular like the relative, *Glyptostrobus pensilis,* the "water-pine" of the Canton delta, for which the species was named. The trunk is somewhat enlarged at the base and the bark is reddish but thin. On the smaller branches the bark is somewhat folded or curled. The lower branches slant slightly downward, and the upper branches point distinctly upward. The wood is relatively light and soft. The foliage is a conspicuous pale green. The needles are flat (fig. 2), on opposite sides of the stem, and closely resemble those of the California coast redwood, *Sequoia sempervirens. Metasequoia* differs from the latter, however, in being deciduous. The cones (fig. 3) are small, nearly round, and resemble rather closely those of the coast redwood in general appearance.

Figure 2. Foliage of *Metasequoia glyptostroboides.*

The foliage, however, is much softer and the twigs and branches quite fragile. These characteristics seem to set it off rather conspicuously from many other conifers. In fact, after the species has grown longer in cultivation, it may be judged one of the most beautiful of existing trees.

The dawn redwood is called *shui-hsa* in Chinese, which means "water-fir" or "water-*Cunninghamia.*" The tree was apparently unknown outside its range before its recent scientific discovery by Chinese plant collectors. Probably its range in recent historic times has not been much

Figure 3. **Cones of *Metasequoia glyptostroboides* (outer two) and *Glyptostrobus pensilis* (inner two).**

more extensive than at the present time. This is suggested by the fact that the wood is not considered valuable, and is not carried out of the mountains as is the wood of *Cunninghamia,* or "Chinese fir." Nevertheless, the species has probably been suffering reduction of numbers over a long period. The fact that it requires a damp habitat and grows along streams makes its survival precarious with the increase of population and the spreading of rice fields up into the higher valleys. Possibly the massacre 300 years ago of most of the people in eastern Szechuan by the Imperial forces for failure to pay taxes may have been an important factor in saving the tree from extinction in recent years. Another factor may be the apparent state of semicultivation under which the tree exists. The fact seems to be that a considerable percentage of the existing trees have been transplanted to their present situations. For example, many of the large trees are in straight rows up ravines, paralleling the small streams. Others are around the farmhouses. Many young and medium-sized trees are in straight rows along the edges of rice fields bordering streams.

The reason for the transplanting of the volunteer seedlings from the shaded ravines to particular situations, often in rows, is apparently based on local superstition. The mountain people have the habit of predicting their crops on the basis of cone development on the trees. Thus a heavy crop of cones on the upper portions of the trees is said to indicate a good rice harvest, and an abundance of cones on the lower branches signifies good results on the hill crops (corn, drugs, herbs, lacquer, etc.). Thus it may actually be that the dawn redwood has been preserved from final extinction more or less by chance. It is interesting to note that the water pine, *Glyptostrobus pensilis,* of southernmost China, is also planted for geomantic purposes, generally along old paths in the delta country.

After observing the soft and flexible nature of the foliage and branches, it is easy to understand how the tree has come to be semi-sacred and used for divination purposes. Particularly when observed in a breeze, the tree has a feathery and somewhat fairy-like appearance, and this seems to suggest its uniqueness.

The principal purpose of our trip was to collect insects and other animals in the hope of finding some ancient faunal elements of possible North American affinity which might have survived with *Metasequoia* and the other ancient trees associated with it. The latest known fossil deposits of *Metasequoia* were laid down in Oregon about 20,000,000 years ago (John Day Miocene). A number of the other genera of trees associated in the same fossil deposits are still found growing with the living dawn redwoods. What is still more striking is that the present dawn-redwood area is the only known place in the world where all of these particular trees, exclusive of *Metasequoia*, are now growing together. Thus we hoped to find some animals which might be descended from species in ancient fossil deposits, possibly contemporaneous with the old deposits of *Metasequoia* which have been found in many places in Europe, North Asia, and North America. We even hoped to find some insects related to those in the present redwood association of California and Oregon. Since fossil birds are extremely few and the chance of wild animals having survived very slight, hope and emphasis were placed upon the insects.

Our group went to western China in two parties. The first party left earlier and went ahead overland to Chungking late in June, going by train through Kwangtung, southern Hunan, and Kwangsi provinces, and by bus through Kweichow and southern Szechuan provinces. The others of us went by plane from Canton to Hong Kong on July 3 and from there to Chungking the next day. Even with a week's head start, the first party reached Chungking nine days behind us. During our wait, my assistant and I made two three-day trips to investigate citrus insect pests and ship their natural enemies to the Citrus Experiment Station of the University of California at Riverside. One trip was to Chiang-chin, a few hours up the Yangtze by steamboat, the other to Pe-pei, a major war-time educational and research center, up the Chialing River. Pe-pei is a progressive small city with public library, museum, park, zoo, and many schools, quite unusual in China, particularly for such a small city.

In the afternoon of July 14 we boarded a ship for Wan Hsien, but after midnight we crossed the Yangtze and then the Chialing River to take a smaller steamer, as the first ship had been taken over by the army. Leaving early the next morning, we reached Wan Hsien at dusk. The

Figure 4. Dr. J. Linsley Gressitt, the author and leader of the expedition.

next day we saw the magistrate and made our arrangements with porters to carry our baggage. The following morning we started our long walk south with a police officer, two guards, and four porters. We first went up the river about two miles in a sampan and crossed to the south bank. Passing the mouth of a small tributary coming from a waterfall, we saw a small rock-slide which peppered with rocks for a moment a river boat tied up at the base of the cliff. The south bank was high, level, and covered with rice paddies between a butte-like limestone mountain and a small gorge with a waterfall.

Farther south the country was irregular and hilly, with generally oblique or subvertical shale strata. Parts of the second and third day took us through mountains of horizontal layers of sandstone, fifty or so feet thick, alternating with softer strata, partly shale, of similar total thickness. This gave a somewhat "Grand Canyon"-like effect, with alternating 50 to 60-degree-angle slopes and vertical drops. The sloping surfaces were generally planted with corn, sometimes up to the highest level, there often being at least three such slopes between the alternating cliffs. Generally there were young pine trees *(Pinus massoniana)* growing on the tops of the mountains. In other areas more or less natural vegetation grows on the steeper, irregular slopes, though corn is often planted on slopes with as much as 65-degree gradient. The more rolling mountains are often clothed only with grass, or with scattered pines or shrubbery, and are used for cattle and horse grazing. Goats are grazed in many of the canyons. None of these animals are milked, but instead they are raised for meat and hides, or as work animals. The horses, which are very small, are sold to traders or officials.

Most of the lower slopes of the canyons are planted to tung-oil trees and corn is grown among them. Melons and beans are also cultivated, as well as peppers and some cotton and tobacco. Rice, of course, is grown where the topography and water supply permit. Scattered groups of citrus trees, mostly oranges, were found in the low hills and along the Mo-tau-chi River, mostly near farmhouses. Some pomelo and tangerine trees were also grown. This was the typical agricultural situation in the valleys up to 2,000–3,000 feet in altitude.

The second day, just past Chang-tang-chin, where we met the Mo-tau-chi River, we were forced to delay a few hours until the river level went down enough to allow the porters to pass along the main trail in the rock bank, which had been overflowed by high rain torrents. At this point there were a few salt mines along the edge of the river. The output is small, however, and most of the salt used in the mountains is carried in by coolies in large slabs of stratified salt mined and brought from the southwest.

The third afternoon we reached Mo-tau-chi after climbing up a thousand feet from near the upper end of the Mo-tau-chi River valley to an altitude of nearly 4,000 feet. I walked past the town and saw my first dawn redwoods, the three originally discovered trees. The large type tree (fig. 5), 90 feet high and 5 feet in diameter (well above the ground) has a shrine at its base. The other two are one-fourth grown. All three are more or less in a row along the banks of the stream, and at the edge of rice fields. My first view of the foliage reminded me vividly of the coast redwood, except for the softer and more fragile nature. However, the drooping terminal foliage and the swollen base of the tree suggested to me the water pine, *Glyptostrobus,* of Canton, which is a relative of the bald cypress, *Taxodium,* of southeastern United States. The dawn redwood also resembles the latter two in its thin bark, light wood, and preference for growing near water. The species, I later learned, had been named just two months earlier, by Dr. H. H. Hu of Peiping and Professor W. C. Cheng of Nanking, who at the same time erected the new family *Metasequoiaceae* to contain the dawn redwood and the extinct members of its genus, dating back, as they do, 100,000,000 years.

The next day, after passing through a heavy stone gateway in a

Figure 5. Type tree of *Metasequoia glyptostroboides*, located at Mo-tau-chi, Szechuan.

small ravine guarding the border of Szechuan Province, we entered Hupeh Province, and then went over a pass 5,100 feet high on the Chi-o Shan range (mountains of the seven humps) and down into a wide, flat valley to Wang-chia-ying. Not far from this market town is the largest known dawn redwood, 8½ feet in diameter and 115 feet tall, but we put off seeing it until our return because of our baggage and itinerary. On the twenty-first we crossed the final pass (5,000 feet) and entered the upper end of the Suisapa Valley (fig. 6), or Dawn Valley as I like to call it.

Figure 6. View of upper part of Suisapa Valley.

The valley was our principal objective and occupied most of our time for the rest of the summer. When the last of our party left, it had become quite cool.

The name Suisapa (Shui-sha-pa) refers to the local, and only Chinese, name, *sui-sa*, of the dawn redwood. Suisapa specifically is only a single small locality in the middle of the valley (fig. 7), but is the best known place, and more or less serves to identify the whole, as it seems to have no other name. Actually, there is another small farming community of the same name in a canyon off the lower end of the valley, near Hsiaoho, the only market town in the 25-mile long valley.

It is this valley which contains the unusual assemblage of plants of

Figure 7. View of the middle portion of Suisapa Valley.

ancient northern affinity, many of them being among the most familiar and conspicuous types of trees in Europe and North America. Among them are beeches, birches, poplars, willows, oaks, chestnut, maples, hornbeam, hop hornbeam, linden, sassafras, pine, and yew. If it were not for the rice paddies, farmhouses, and people, a European or American might believe himself near home. Forests of the extent found in this valley are rarely seen in China except on the steeper slopes of high mountains, and in precipitous canyons or temple preserves. Immediately on entering the valley, one cannot but sense its uniqueness, both from the standpoint of the unusual nature of the flora and from the extent of its preservation. Probably one reason for the slower rate at which the trees are being cut is that the nearest large commercial center is Wan Hsien, 120 miles walk to the north, and in another province, whereas the stream in the valley flows in the opposite direction for a short distance underground just outside the valley, and then a very long distance, round about, with dangerous rapids and narrow gorges up which boats may not be towed, before meeting the Yangtze River between Chungking and Wan Hsien. Foresters who might dare to float rafts of logs downstream would have to dispose of their poles and ropes and walk back. Though trees are being cut locally at a seemingly alarming rate, they are used mostly for local purposes, particularly for houses, fuel, and coffins. Coffins are made from trunks of *Cunninghamia* and carried out of the mountains as a business.

The valley extends northeast and southwest and curves eastward at its upper end. The lower end is more or less closed by an east-west range of hills, the stream passing through a break in them, and continuing beyond to the southeast for a few miles, partly underground. On each side of the valley extends a fairly sharp ridge, the east ridge reaching 5,500 feet and the west ridge 5,100 feet in altitude. The east ridge has a number of side ridges extending far into the valley and causing bends in the river though the valley is fairly straight. Some of these side ridges are very steep, narrow, or many-branched, and some broader. The west ridge is rather uniformly narrow, being steep on each side, with only a few short side ridges. It is quite irregular, with several peaks and depressions. The east ridge is more regular along most of its skyline, decreasing in altitude towards the south. On the east side of it there is a considerable drop into a large, deep valley which slopes much more steeply to the south than does Suisapa Valley. On the west side of the west ridge, however, the drop is only several hundred feet except at the north. Immediately to the west is a large, flat-topped, treeless range of much different appearance from the others. It is the highest in the near vicinity except for Mt. Sun-sin-po to the south, located not far southwest of the lower end of Dawn Valley.

We made our headquarters in one of the two large farmhouses on the east side of the stream at Suisapa. Part of this house was occupied by a former mayor, and the present mayor lived in the other house. Since Dr. Chaney's visit four months earlier, the mayor's wife and one child had died and the mayor was now sick. We therefore could not live in his house, and had to be somewhat careful until we had made friends with the people, as they tended to ascribe this bad luck as caused by the foreigners coming and cutting down a dawn redwood for specimens. However, the local people themselves cut the trees not infrequently. There is a prevalent local custom of cutting the branches off the *Metasequoia* and *Cunninghamia* trees periodically, often almost to the very top, at least for the trees close to their houses. Thus most of the trees outside the shady ravines are apt to have an extremely slender appearance as new branches are growing out (see figs. 8 and 9). Sometimes the trees are thus killed, as had recently happened to two large metasequoias next to our farmhouse. For those not killed the practice reduces the potential self-seeding of the trees.

In the canyons near our headquarters, which included many of the large trees outside of farmyards, we found quite a few young seedlings. This indicates the species is not senile, but is still able to reproduce itself. On close searching among the boulders and shrubbery we could often

Figure 8. Two pruned *Metasequoia* trees.

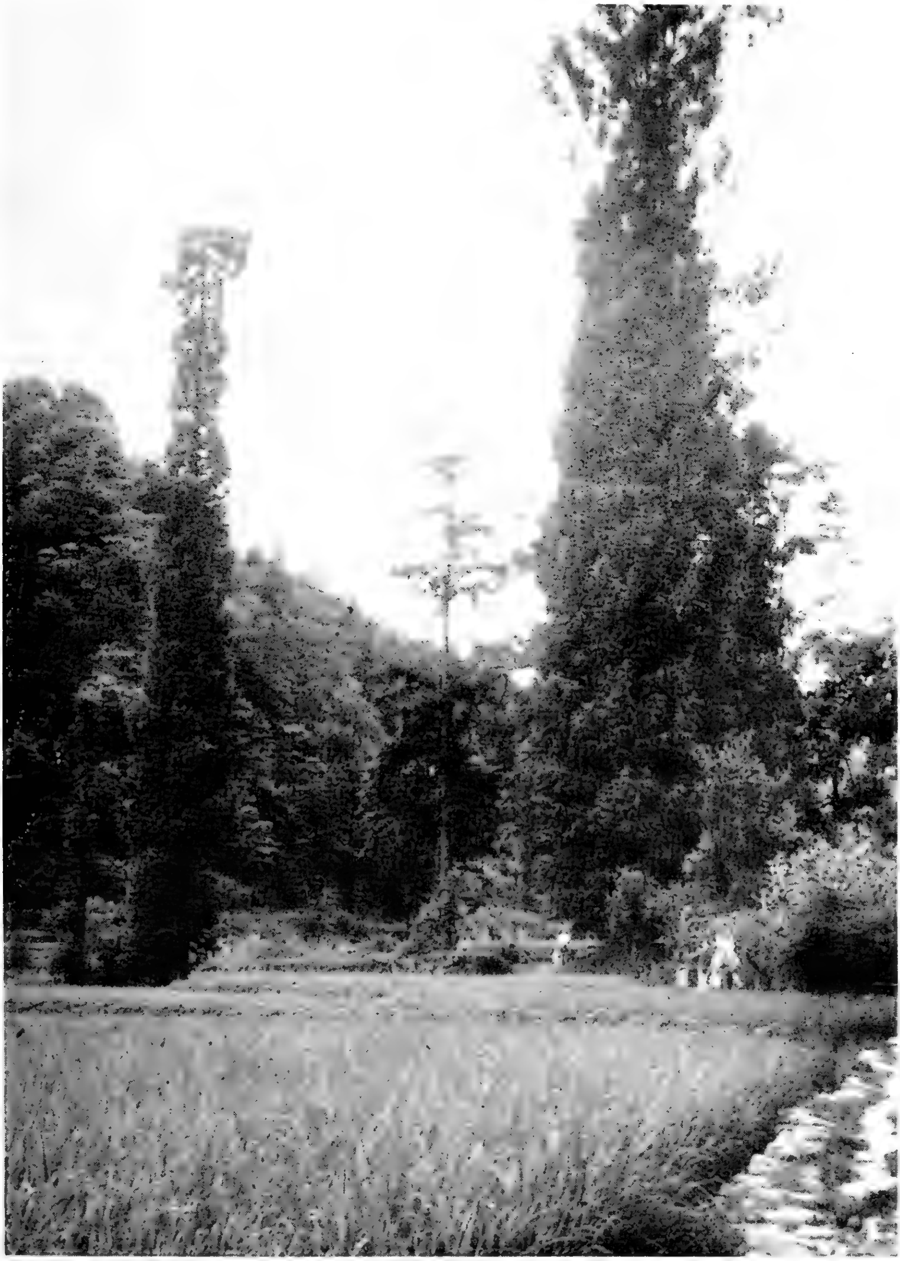


Figure 9. *Metasequoia* trees on floor of Suisapa Valley.

Figure 10. *Metasequoia* trees, south-central part of Suisapa Valley.

find at least as many very young trees as large ones. Though the trees are generally erect, sometimes young trees have widely spreading branches, making them as broad as high, like yew trees in the valley.

The dawn redwoods are found scattered throughout the valley (fig. 10) and in some neighboring valleys to the immediate south. They are most abundant in the shady ravines branching from the central portion of the valley, though there are some large groups in certain spots near the southern end. Many young ones are also planted along the main stream, bordering rice paddies. In the upper portion of the valley they are scarcer. Their altitudinal range is approximately from 2,000 to 4,000 feet. There can hardly be said to be any *Metasequoia* forests or even moderate natural stands. Most of the trees are in rows following up side streams (fig. 11). There are rarely as many as 50 along a single branch stream.

Figure 11. Straight row of *Metasequoia* trees along a small stream in a side valley, Suisapa.

On arrival at Suisapa we dispensed with our guards and decided we would just forget about bandits in spite of the warnings about them. One of the guards who came over the pass with us from Wang-chia-ying, whence our Wan Hsien escort returned home, told me there were 2,000 bandits across the second range to the west. A resident of the valley, who had been returning along the road with us, warned our guard at Wang-chia-ying that a group of bandits were trailing us, but they turned out to be plain-clothes guards tracking bandits. The wife of a bandit who had robbed one of our guards on a previous trip had been apprehended in a village along our route and was interrogated by the officer during our evening there. In spite of a total of six one-way trips we made between Wan Hsien and Dawn Valley, as well as several side trips, we had no bandit encounters.

Our actual host in this farmhouse was an old widower, who had only one child with him, a son of 16. We ate and worked, and two of us slept, in his main room. The other four of our group slept in the opposite wing. He and his son slept on low, single-plank benches on each side of the open hearth fire in their kitchen, keeping the fire burning all night. These houses were of wood and had no chimneys. The smoke filtered out through the tiles in the roof, and through the small windows. The roof beams or bamboo drying frameworks above the fire often dripped an oily pitch and were thickly encrusted with cinders. Rice was cooked in a large iron pot and other things in a large concave iron pan like a slice from the edge of a sphere.

The local food consists mainly of rice, corn, white potatoes, beans, squash, peppers, some Chinese greens, cabbage, and eggplant. The peppers are very hot and are eaten unmixed as regular dishes in every meal as well as flavoring for most other dishes, so we found their meals unpalatable. Actually they eat few vegetables fresh and pickle most of them, mixed with peppers. The corn they often eat as corn-meal mush. We found it hard to obtain sufficient fresh vegetables. Also, most of them were not harvested until oversized. The people made their own bean-curd, but never had any they wished to spare, so we bought it only at the market, where also we got our only meat. Fortunately, we were able to buy eggs most of the time, but could only get enough by buying several dozen every market day (every three or four days). Food was cheap and inflation was behind time here. We bought eggs as cheaply as 200 to a United States dollar. Beef was purchased as cheaply as two cents U.S. a pound, but we were only able to obtain it twice during the summer. Pork cost four times as much.

Most of our breakfasts and suppers, except the day after market day, consisted of rice, boiled potatoes, and soup containing eggs, a bouillon cube, and a little pork fat, with sometimes a green vegetable. Lunch consisted of one or two eggs and two or three small potatoes boiled and carried along with us.

Though the food of these people seemed poor, they had quite enough of it for themselves, and in some respects they were rich. Though they had next to nothing of a ''civilized'' nature except their cooking utensils and carpentry tools, they could raise all the food they needed and sell some, plus plant drugs, mushrooms, and the like on the market or to the outside world. They build their own houses and coffins and also sell some of the latter. Here their coffins were very large, utilizing the basal portion of at least one *Cunninghamia* tree three or four feet in diameter for each. While we stayed at Suisapa three coffins were made in this house. About four families lived in this large house. The room next to ours was used for rice storage for the neighborhood. It was sealed up, but every few days it was opened when many people came to draw rice. On each side of the house was a row of animal pens, housing cattle, horses, and pigs. Great pits beneath the slat floors collected all waste products, which were used for fertilizing the fields. Chickens lived in or under the house. Our two rooms had wooden floors, but dirt floors were more common.

The language of these people was rather different from proper Mandarin, or standard Chinese. Though only a variant, and hardly a dialect, it was somewhat difficult to carry on conversations. For clothing, as in Szechuan Province, the people almost always wore long gowns of fairly thick, blue, home-made cloth reaching almost to the ground. This was true for men, women and children, and beneath this they usually wore jackets and long trousers of the same material. For their considerable idle time, when they smoked their four- or five-foot long pipes, gossiped or stared at us, their garments seemed suitable, but when they worked they appeared too warm. In the fields, cutting wood, or collecting for us, they would often tie up the long gown around the waist.

These people did not seem to be given to music as are people of many parts of China. However, one use for it was quite impressive. A type of native communism existed here, whereby quite a bit of the agricultural operations were cooperative. A group of ten or more people would generally cultivate together, with their iron hoes. They all worked in unison to the beats of a cymbal and a drum. The leader sang out short chants, and the whole group joined in the chorus, to the accompaniment of the leader's cymbal and the drum of his assistant. The tempo of the work was not fast, and there were frequent pauses when all rested. Though I often heard these musical work-gangs, I only once came within close range of one, on a steep hillside cornfield. I was prevented from getting a picture by curiosity toward me breaking up the routine, and by the lateness of the hour. These people rise before daybreak, doing much of their work in the early morning and late afternoon, and have supper at eight or nine in the evening. They find quite a bit of leisure in the middle of the day. Though these people are Chinese, there is clear evidence in their faces and stature that here in these mountains they possess quite a bit of aboriginal blood. The aboriginees were apparently reduced and absorbed as the Chinese pressed into the mountains. The imprint of the former remain in rounder faces, thicker lips, and browner skin than possessed by pure Chinese.

In order to make our efforts more effective, we employed a widow to cook and wash clothes for us. Her trachoma (almost universal here) was so advanced that her eyesight was very feeble, and the first day she lost a small pocket knife and a pair of undershorts while washing clothes in the river. We also frequently found hair, flies or other foreign objects in the food, tea leaves in the rice, etc., even though one of the boys supervised most of the cooking. We tried not to think of germs too much. We also employed from two to four local boys or young men by the day to help us in collecting. It was hard to teach them to collect the small insects, and most of their catch consisted of the common butterflies, dragonflies, and grasshoppers. They did help by carrying the plant-press, lunch, large cyanide jar, and other equipment, but they did not like to work every day.

Our principal emphasis was on insects, particularly those in association with the *Metasequoia* and other interesting plants of the valley. The plants we collected principally for the purpose of identifying the host-plants of the insects, and the serial numbers of the plant specimens were assigned to the insects collected on them. To all the local people we met we advertised our miscellaneous needs, offering to buy all kinds of animals. The returns from this method of acquiring specimens were less fruitful than I had experienced in some other parts of China, perhaps because these people seemed to have less use for money. This was also reflected in the fact that we could not count on our hired collectors coming every day. We often lost time waiting for them in the morning, or persuading some younger boys to go along in their stead. One of our more faithful helpers would not go up the main valley past a certain point, and we could only assume that it was for fear of being kidnapped to help fill the conscription quota of another community.

Gradually, as a result of making rather high payments for specimens brought in, we acquired a certain number of snakes, lizards, frogs, and birds, but almost no mammals. The people stated that the summer was not the season for hunting, and they adhered to their custom. One of the reasons given, in addition to the fact that the animals are harder to find in summer, was that the summer was the breeding season. This, of course, was a commendable viewpoint.

From questioning the inhabitants, we gathered that tigers, leopards, wildcats, bears, deer, mountain goats (serow or ghoral), muntjacs, foxes, civets, wild pigs, rabbits, squirrels, and others occurred here. Someone told us there was a family of leopards with small young at a certain point in the valley, but that was all we heard of them. One day I saw a long-tailed, slender, black and white animal which may have been a kind of civet. Once one of our boys saw a large dead cat at market, but could not buy it. The only specimens of mammals we got were moles, mice, and bats.

Among the common birds in the valley were sandpipers, a large gray heron, Chinese pond heron, green heron, egrets, a blackish heron, night hawk, black-eared kite, kestrel, dove *(Streptopelia)*, water-cock, ring-neck pheasant, golden pheasant, woodpeckers, swallow, water-ouzel, forktail, dayal bird, violet whistling thrush, plumbeous water redstart, gray tit, crow tits, scimitar babblers, quaker thrushes, other laughing thrushes, Chinese bulbul, yellow-vented bulbul, Chinese finch-billed bulbul, wagtails, buntings, tree sparrow, munia, magpie, blue magpie, crow, collared crow, tufted mynah, and drongo.

Among the reptiles here we obtained soft-shelled turtles, skinks, water snakes *(Enhydris)*, green grass snakes *(Euryphohus)*, species of *Elaphe* and *Natrix*. Of poisonous snakes there were two species of *Trimiresurus* (pit vipers), one of them a green bamboo snake. One of the latter I found at the summit of the highest peak on the west ridge, just after it had caught and swallowed a rat. Amphibians here included a large toad *(Bufo asiaticus)*, many tree toads, and frogs of several species.

In our daily collecting we generally divided into two groups, at least after lunch, as there were as many as nine of us collecting at one time. We attempted to collect along each ravine and ridge, to investigate all types of floral situations. We reached the east and west ridges at several points, and collected in the high valley to the west several times. Much of our collecting consisted of sweeping the vegetation, one species at a time, when possible, to collect the insects from each kind of plant. At other times we worked on dead branches, fences, logs, stones, streams, and rotting materials. When there were no trails up to the passes or peaks, we had rough going through very dense vegetation (figs. 12 and 13), or had to detour.

When on the higher ridges or peaks we observed from several points what appeared to be two high, more or less flat-topped plateaus some distance to the south. These began to fascinate me since it was among our objectives to find how far south the dawn redwoods extended. Also the possibility of other ancient plants or ancient animals having survived on a large, high, isolated plateau intrigued me and spurred the imagination. Consequently, we made inquiries, and on August 2 I started out for the mountains with one of the boys and our host as guide and porter. On the same morning my assistant returned to Wan Hsien with a porter to ship specimens and send back equipment and food. The others remained at Suisapa and collected.

Our trip commenced by following the valley south a few miles and then crossing the east ridge at a pass 4,000 feet high. We then followed

Figure 12. Side valley connecting with the eastern portion of Suisapa Valley.

Figure 13. Margin of the middle portion of Suisapa Valley, showing terraced fields and forests above.

down a stream which went south and gradually became a river (Chen River) as it received streams from the large valley to the north. Along this narrow valley, which in parts had some vertical cliffs, we found a number of small groups of dawn redwoods, some apparently growing wild and others in farmyards. Almost without exception each farmhouse had one or more large trees beside it. In the upper part of this valley, as in Dawn Valley, this place was generally held by *Metasequoia.* In other places, as farther down this valley, the species was apt to be a large *Cupressus* (no. 2505), ginkgo, or rarely pine *(Pinus massoniana* or *Pinus* no. 2536).

The redwoods continued as far down the valley as we followed it that day, down to an altitude of 2,400 feet. The next day we saw what seemed to be one across the river at 2,200 feet (Tsung-lo). As the altitude lowered, pine *(Pinus massoniana)* gradually replaced *Cunninghamia* as the dominant conifer on the sides of the valleys, and the cupressine (no. 2505) also became more common, not only in the farmyards. The greater scarcity of cunninghamias in these lower valleys, however, is at least partly due to foresting and denser population.

As we approached a turn to the south in this eastward-extending valley and then crossed on a bridge to the south bank and started to climb the ridge, I began to wonder strongly if this trip was really bringing us to the high plateaus we had observed. We had been surprised when told that the mountains about which we had inquired were only one day's walk away. After climbing a little more than 1,000 feet, we reached the farmhouse at which we were to stay somewhat past midafternoon. This was located only a short distance below the crest of the ridge. I inquired about the flat-topped mountains, for which we had been given the name "male and female (peaks) on big-dike plateau." The answer was that they were just a short distance away to the east on this same ridge, hidden by fog. After a few moments the fog thinned enough to see two erect finger-like rock formations near the eastern end of the ridge. Obviously in trying to describe the plateaus to the villagers our remarks about vertical sides, flat tops, and two very much alike, had suggested these landmarks, which though conspicuous, differed exceedingly in size from our goals. Instead of a few thousand, they were a few dozen, feet high, and instead of ten miles or more broad they were only several yards broad. There were some other similar rock structures on other ridges in the area, but the others we saw were single.

I walked up to the ridge and looked south, but could not make out my plateaus clearly. I followed the ridge west up to the top of the nearest peak, 4,000 feet high. It was covered with trees, but from part way up, at a cornfield, I had a view in the right direction. The mountains seemed more irregular and less like plateaus. They did not stand out so conspicuously and there were peaks in front of them. Returning along the ridge I went in the other direction to the foot of the male and female peaks. I hurried back towards the farmhouse, as it was getting dark. In leaving the ridge I took a path which led down through the forest to the wrong farmhouse. I had trouble inquiring, not knowing that our place contained the local school. I rushed down some further trails calling my boy, and was finally answered after dark. We spent the evening trying to dry out clothing and bedding which were wet from heavy rain during the day's walk.

We had planned to spend three days on this trip, the second day climbing the mountain and collecting, but I decided to push on as far as we could go the second day and make it a four-day trip. The next morning we started early, leaving our guide to wait for us, and taking no mosquito nets or blankets. We crossed the pass and descended to Pa-sen-taau by the river below its 90-degree bend around this ridge. We found that the good trail was on the other side, but could not cross to it. We saw a bridge submerged in the flooding river, a little below. We had a good deal of up and down as the path could not follow the river because of cliffs. At one point we forded a rushing stream which seemed to flow out of the side of the mountain above us. It did, in fact, do that, and was the river from Suisapa Valley, which sinks underground about two miles below Hsiaoho and before reaching this ridge. We arrived in Tsung-lo, a market town, in the early afternoon and after resting pushed on, crossing the swift river in a tiny one-passenger boat, which the boatman carried down to the bank over his shoulders. After passing some citrus orchards, we reached a narrowing in the valley where a tributary came out of a gorge and met the main river at an angle of over 200 degrees and then entered another gorge. This formed a "Y" with the stalk turned to the right, the left arm and stalk being the merging tributaries. We crossed the east tributary on a high-roofed wooden bridge across the mouth of the gorge and climbed the steep-stepped rock path up the ridge between the two narrow gorges.

On the opposite face of the entrance to the south gorge the very steep slope was cleared of its dense vegetation in the middle to expose thin strata of hard shale that were tilted almost vertically and exposed at right angles. This clearing was planted to young corn. How the farmers reached the middle of this near cliff was a puzzle to me. Both the gorges cut through solid limestone.

As we climbed, from the 1,800-foot river level, a downpour threatened, so we decided to stop for the night at a house at the 2,750-foot altitude (Lung-keu-po), being out of breath from hurrying. After resting as the storm blew past, I went on alone to see how close we were to the plateaus. There was a continuing series of peaks of increasing height on the top of this range. Though I scaled one, 3500 feet high, passing through tall, wet grass, cornfields, and pine groves with brambles, the view was hampered and it appeared that we had gone too far to the east and in too roundabout a way to reach our objective. Along the trail, between these conical peaks, were some of the serried, sharp limestone projections representing peculiarly eroded, vertically tilted limestone strata. These had also been conspicuous on the Chi-o range north of Suisapa. Here there were also some deep conical sinks like craters which, however, contained no water in spite of the heavy rains. The next market town to the south along this route was Sa-chi, about 12 miles farther.

After I returned we had a peculiar supper of rice and potatoes boiled together, something new to both me and my boy, and string beans. Our bouillon helped out. That night neither of us could sleep at all, the bedbugs, fleas, and mosquitoes were so bad. We rose early and walked the ten miles to Tsung-lo for breakfast. For our return to the twin peaks, we left the river and climbed the ridge and followed it to the end. It was amazing to see the extent of rice terracing and the number of farmhouses and people on the steep slopes of this high ridge. Some of the peaks and some branch ridges to the west, however, were well forested with *Cunninghamia,* birch, beech, oak, chestnut, pine, and other trees. Returning to our farmhouse somewhat early and leaving somewhat late the next morning, I had more opportunity to associate with the people. The students of the school (all boys) were interested in our insects. They all smoked, and many of the younger ones had their small bamboo pipes, of various types, tied to their clothing with a piece of string as our young children might have a handkerchief pinned to their shoulder when going to school. In conversation we learned that seven miles east, at Lung-shen-tai in the mountains across the river, there was a group of dawn redwoods including one apparently about five feet in diameter. This may represent the eastern limit of distribution of *Metasequoia.* We returned as we had come and completed a somewhat strenuous 100-mile trip.

The next day we collected high along the west ridge again from Suisapa, and on the following we moved our headquarters to the Hsiaoho temple, just outside the south end of the valley and a mile south of Hsiaoho market. Actually, the small, rather rundown temple proved to be a nunnery in the sense that the caretakers were three nuns. During the daytime the local school operated in a room on our side of the court. We had a small room nearly filled with three built-in beds for the five of us. We barely found room for an old table between the two beds near the single, papered, outside window. Below our room, side-by-side, were the pigpen and toilet, and below them the common receptacle for human and porcine waste products. In a dirt-floored room nearby we built two stone fire-places and above them, suspended from the rafters, our ropes and baskets for drying plants and insects.

That afternoon we hired two new collectors and in the morning ascended the steep peak just north of the temple, which was the western end of a ridge extending to the north-south ridge between the twin peaks and Tsung-lo which we had traversed four days earlier. Though the altitude was just over 4,000 feet, we had a fair view to the south, as the nearer peaks in that direction were not high. From some villagers who had ascended with us, we gathered more definite information about the country to our south, though we still did not learn the names of these plateaus. Descending the north side of the ridge, we came on some farmhouses where the people made bamboo paper by soaking the bamboo culms in lime pits under heavy stones. We bought some paper for pressing plants and packing insects. In the valley at the foot we reached the other community by the name of Suisapa, though here there were not so many dawn redwoods. In one yard we found a tall, straight, whitish-barked pine. (*Pinus* no. 2536) with cones shaped something like those of knob-cone pine, though without the knobs. On my return to Wan Hsien I noticed quite a few young trees of this species just south of Mo-tau-chi, the northernmost *Metasequoia* locality. On our way back to Hsiaoho we were soaked by a downpour.

The next two days we collected in various directions, operating in two groups. We found less forest in this area, but a wider variety of collecting situations. The altitude of the river here was just over 3,000 feet. From one of our friends in the market we obtained further information about the country to the south, and I planned another trip, this time taking the youngest boy in our group, but no guide and no baggage except camera, altimeter, pure DDT powder, some food, extra socks, and our collecting gear.

We started early on August 11 after eating some tough roast chicken and cold rice, some of which we took along with us. We went south, and even a little southwest at first, through a low valley which had some more of the rows of limestone projections, as at Chi-o Shan, and Lung-keo-po. There were cornfields and lacquer trees in the valleys as well as on the hillsides, as the drainage was apparently not suitable for rice cultivation. After crossing a ridge, we headed south over somewhat level country into Szechuan Province. At Wen-tu, a market town near the border, we rested in a teahouse during the middle of the busy market day. From here we headed southeast along a ridge which dropped down to a low valley. From this ridge we had some striking views to the south and east of some horizontal stratified mountains etched by gorges and some conspicuous erect remains of others rising from lower surrounding country. We descended our ridge obliquely from 3,400 feet, coming down through tung-oil trees and corn to the gorge of the Chen River as it narrowed and penetrated these massive stratified mountains at 1,500 feet. We were many miles down river from Tsung-lo, and were close to 40 miles airline south of the ridges at Suisapa, as we covered nearly forty miles walk on this first day. Though I did not fully realize it at the time, we were actually entering the nearer, and western, of our "plateaus," and the gorge cut by the river at this opening was a notch we had seen in the middle of its skyline. Instead of a plateau it was a large area of mountains of thick, horizontally stratified limestone cut by streams into buttes, pyramids, peaks or less, but with about the same maximum altitude; barely over 4,000 feet. The impression of high plateaus with altitudes of perhaps 7,000 feet was an illusion caused by their distance, being massed close together with a fairly solid northern face and abrupt eastern and western edges, as well as being seen over what was not recognized as hills of southwardly decreasing altitude from the ridges over 5,000 feet high to the north. I was also influenced by believing that these might be mountains mistaken by United States Air Force fliers for those having the dawn redwoods, and reported as being over 7,000 feet high.

After entering the gorge for a short distance, we crossed the river in a sampan ferry at the mouth of a tributary from the east. The mouth of this tributary was peculiar in that though seen as a sizable stream farther up, and within view from the mouth, very little water actually passed the near dam of gravel just before its mouth. On the other hand, a rushing stream came out from a large hole in the foot of the cliff on the north side of the mouth, a few feet above the stream level. Continuing up this east tributary, we passed many small waterfalls. At one point far up on the north side, we noticed a gushing waterfall at the highest visible cliff level, seemingly near the top of the ridge, whereas at the lowest cliff level there was only a trickle of a waterfall. This could hardly have been caused by a very recent downpour on the ridge, or we would have seen the lower waterfall increase in size before it was lost to view. The circumstance suggested that the water from the higher falls went into a tunnel in the limestone rock and perhaps became the subterranean stream which opened at the mouth of this gorge.

There were quite a number of goats raised in this canyon. The houses of the people who tended them were cliff dwellings, or partly so, being mostly in cavities formed by overhanging limestone cliffs, walled in front with rocks or woven bamboo. This vegetation in the ravine was almost semijungle, where it had not been destroyed for grazing or cornfields. At some points where it was being cleared, there were cave-ins, or small landslides.

After the canyon widened out to gently terraced rice-field slopes, we reached Lin-sui. The elders of this small market urged us to spend the night there as it was too late to reach the next market over a high pass, but we pushed on and stopped at dusk in a small farmhouse on the way up to the pass, near the upper limit of rice and tung-oil trees. The next morning we continued up to the pass at dawn. Some of the steep slopes were grassy with scattered *Cunninghamia* trees, and others bore bamboos or hardwood forests. We seemed to cross this ridge at nearly its highest point, 3,400 feet high, and gradually descended the slopes of a branch ridge from a pine grove, through hardwoods, down to tung trees and corn again.

Descending further to rice fields we reached the hamlet of Suen-wu, where there were a few relatively wealthy-looking homes with stone walls. Here we saw two trees of an interesting conifer *(Juniperus* no. 2535) with drooping branches and long, sharp needles. (We had also seen one on the approach to the ridge.) We followed down a willow-bordered stream, crossing it many times on stepping stones till we reached a point where it had to be forded. Being hot and tired we took a swim. As we continued, a powerful gusty wind came up in the now broad valley, but we reached Pa-se-kwan market just as the shower struck. After a rest and a late lunch of our first warm food for the day—rice and hulled corn boiled together, stewed melons with a suggestion of pork fat and quantities of tea—we continued southeast over a little-traveled route. Crossing a hill, we were confusesd over our directions, but came to where two boys were carrying wood across a river, and found we had to ford it. It was muddy and swollen from the recent shower and we had to strip and carry our things overhead as the swift water came to our chests and taxed our strength. Traversing more hills, partly covered with rice paddies, we passed south of a small hamlet, now traveling east. In spite of inquiring of each farmer we saw, the simple directions broke down as the tiny path curved and branched among paddies or terraced corn or beans. Seeing two farmers we made our way to them to inquire, but they refused to understand our questions, and thought it a big joke, though we only asked the way to the nearest market town. We continued upward towards the long ridge to the east, knowing we had to cross it at some point, till we found farmers who got us on the right path. Each one we asked quoted us a different distance to our destination, but finally we crossed the ridge at 2,400 feet and met two porters going our way as it became dark. We stumbled down the path for nearly two miles after dark until we reached the market of Pa-hou-keo. We were so tired we dozed until our supper of green beans, dried beans, and rice was ready.

The next morning we left in the early morning fog, and never really knew what Pa-hou-keo was like, except that it was a very small market in somewhat of a canyon with quite a bit of rice cultivation. We climbed again towards a ridge, passing rice paddies, tung-oil groves and some pine, oak, and other native vegetation. We breakfasted at a large farmhouse by the trail under some large cupressine (no. 2505) trees. From the pass, at 2,400 feet altitude again, we had a good view to the south. The valleys were deeper, and in part wider, but still the mountains were of the repeated thick limestone layers, and with about the same average maximum height. One prominent vertical peak some distance to the south was probably the one down on our itinerary as our possible ultimate destination, though we had already realized that was much farther than we would have time to reach. There was by now no question that we had been passing through our "high plateaus," and that my dreams were unfounded. These canyons were apparently quite unsuited for the support of dawn redwoods, as their bottoms were too low, their sides mostly too precipitous, and their tops too dry or too exposed.

Descending again through forest, then tung groves and corn, we reached the Shanghai-Chungking highway in a relatively wide valley bottom with a small river at the market of Liang-wei-tan, at 1,100 feet above sea level. After a large lunch of noodles and our first eggs of the trip, we ended our southward march and headed east along the highway towards Chien-chiang, to return north by another route.

The highway wound along the sides of canyons, with some switchbacks and tunnels. Our route was partly by short-cuts, including a climb over a pass. Beyond this pass, the valley leading to Chien-chiang became fairly broad, with some large, nearly flat areas of rice fields. The population became quite dense, and there was considerable coolie transport along the highway, though we saw no vehicles pass along the road. Having 20 miles to cover after our near midafternoon start, we did not reach the city till well after dark. We were too late to get a regular supper, so again had noodles and eggs. We then found what was apparently the best inn in the city, at the bus stop. While bathing with a basin of water in our room, and tending to some developing sores on my feet, we had several visits from the authorities who were somewhat put out because I had left my passport in Wan Hsien and neither the boy nor I had brought along from Hsiaoho our official letters from the university. The only identification we had was my name card. That night we suffered severely from bedbugs, and I killed over fifty on my bed during several occasions when I forced myself awake enough to rise, light the lamp, and hunt them down.

Chien-chiang (Kienkiang Hsien) is a large town, the largest by far we had seen since Wan Hsien. It is a district city, one of the two easternmost of southeastern Szechuan Province, and not only is near the Hupeh border, but is likewise not very far from both Hunan and Kweichow provinces. From here we ascended the south end of a range and traversed the side of a large broad canyon with partly precipitous sides, still of the same thick, horizontal limestone pattern. We then crossed some passes and descended into another valley with a small river which we had to ford. Here naked fishermen were casting their weighted throw (umbrella) nets and catching small fish. They would dive down and catch some of the fish for certain before pulling in the nets. As we watched after our swim one of them came up with the anterior end of a wiggling nine-inch fish in his mouth, to the amusement of the growing audience. We followed this river to its headwaters, and had to cross it many times, first removing shoes, and as it became small, taking running jumps where there were some partial stepping stones. The frequent wetting did not help the sores on my feet, which had originated from bedbug bites except for one blister on the top of my right ankle. During the afternoon we had our first heavy rain of the trip, and felt cool, being unprotected from it, whereas it had seemed intensely hot in the lower part of the valley at midday.

We reached our stopping place for the night, a hamlet of four houses, just at dark. Our host, an aged, somewhat confused man, was not particularly hospitable, as the tiny inn was already overcrowded. The food, again, was poor, but the boiled potatoes were welcome once more as a change. The inn consisted of two rooms, one the kitchen. My boy and I shared one bed, and other guests were mostly on doors and boards in the center of the room. The next morning, as usual, we started out in the early fog without breakfast. It rained on and off during the morning. We seemed to be crossing numerous passes between branches of a stream system until finally we came out to a large deep valley again. At one small hamlet we found some men chopping up two thirds of the left side of a pig, and marketing it, though only a few people were present, and it was not a market. We bought one catty (1⅓ pounds), but had to carry it for quite a distance before we found a farmhouse where we could cook it. Though it was practically the first meat we had seen on the trip we ate so many toasted cakes of pounded rice while the meat was cooking and the rice being heated that we had to carry nearly half the meat on for supper.

On towards the middle of the day we passed through a small market town, and descended to near the river in this large valley. We were somewhat confused by being told widely varying distances to our destination. The river flowed northeast and then north till it met the Chen River, some miles above where we had crossed it four days before and equally far below where I had seen it disappear in a deep gorge on the previous trip eleven days earlier. We found when we reached the main river that we were on the wrong side of the tributary for the regular crossing, having been uncertain about our directions where a branch of the trail had lead to a ford not long before. However, the boatman managed to push upstream above the branch and then crossed with us to the northwest bank of the Chen.

We now traveled northeast along the west bank of the Chen River. The trail passed along steeply terraced rice fields, and we were constantly losing our path and taking the wrong paddy embankment. This route was apparently a very little-traveled one. Gradually the valley became narrower until it was a gorge, and we passed along a trail partly cut in the cliff till we came out to the mouth of a small tributary from the northwest. Here we noticed that both the river and the tributary entered steep limestone gorges, and between them, on the north, was a large cliff in the middle of the steep slope leading up to the summit of a high ridge. I realized we were approaching the terminus point of my previous trip, and I supposed we would cross the river here to the east and continue on past that point (Lung-keo-po) to Tsung-lo. There was a ferry here and a number of people crossed over to our side. We questioned them, and though the first few did not seem to realize that we were trying to speak their language, we finally learned that they were returning from market at Sa-chi, the town we had fallen 10 miles short of reaching on the first trip. We also learned that it was shorter to go to Tsung-lo in the direction in which they were traveling. I was puzzled as to what that way could be, but gradually came to understand, as we climbed up the partly forested steep slope and began climbing obliquely up the face of the cliff on steps neatly cut in the limestone at a point in the cliff where there was an indentation, even possessing some vegetation, mostly small trees, shrubs, and vines. Above the cliff was a steep slope of corn, with forest near the top. Reaching the forested pass, only slightly below the crest of the ridge, we found the altitude 3,100 feet, whereas the river was 1,600. That 1,500-foot climb after over 30 miles of rough going on sore feet was a bit exhausting.

After resting and eating some roast field corn we continued and found that we were going north along a ridge which only gradually decreased in altitude. Passing a small hamlet Fu-chia-tang, just before dark we found five *Metasequoia* trees along a path between rice fields at a point where the side of the valley became steeper below. This is the southernmost known limit of distribution for the tree, though it did not extend the range more than about ten miles farther south (latitude 29° 45′ N.), than we found it before. We started down the slope, but as it got really dark and the moon was now behind clouds, we gave up the idea of reaching Tsung-lo that day, and retraced our steps to the hamlet. In asking for a place to stay, we were finally directed to an inn two miles north. It developed that it was on a trail to Hsiaoho, and that we did not need to go to Tsung-lo. A man guided us along the trail until there were no further branches to confuse us, but we found the path full of rocks and puddles and thus the going inconvenient. We reached the small inn, a lone farmhouse on the trail, while supper was still being cooked, and had one of the best meals of the trip: rice, green beans, bean curd, eggs, and our pork, not to mention the peppers and cold pickled and peppered vegetables which we did not touch. After our 40-mile rough walk we were greatly annoyed to have to get up and fight bedbugs immediately after retiring. We got some brands from the fire, poured some vegetable oil on them and also burned some straw we found, in order to get light for searching out the bugs, as we could not find any of the vegetable oil lamps and everyone had retired. We just avoided burning the house down when we ignited our straw mattress. After killing several dozen of the bugs we threw the aged quilt to the other end of the room. In spite of all the time we spent in the hunt, we still had the bugs, and slept poorly.

Our remaining 13 miles or so to Hsiaoho was done before breakfast (except for an egg apiece), arriving at ten o'clock. We passed through country similar to that south of Tsung-lo on the other side of the river: fairly high, somewhat level country with small hills here and there as well as dry sink holes, and the same peculiar rows of erect smoothed limestone projections like long rows of sharp canine teeth. This continued, through cornfields, practically all the way after getting out of the valley in which we had spent the night, and until we reached the trail down which we had started the trip, a few miles south of Hsiaoho. Thus ended our somewhat disappointing 165-mile, 5⅓-day trip.

Knowing that the porter would have returned before us, from Wan Hsien, with equipment and food sent back by my assistant, I was all anticipation for mail, not having received any for a month. Though the porter had returned several days before, to my keen disappointment there was no mail, except a note explaining that some mail of ours had been forwarded previously to Mo-tau-chi from Wan Hsien, and that the post office had been asked to send that mail on to us. We never received that batch of letters. That evening I received two letters forwarded from Chungking, the first we received at Hsiaoho, but neither was from home.

The next day, August 17, we moved back to Suisapa, and reoccupied our former quarters. We took with us two collectors we had trained at Hsiaoho, in order to have at least two regular ones to count on. But even these generally went back to Hsiaho on market days, so we took advantage of that in having them carry back food for us. On the nineteenth part of our group left for Canton, with our accumulated collections and three dawn-redwood seedlings. On this day and the following two I tried to collect as usual each morning, but found it impossible, as my feet had become greatly swollen and the sores very large and painful even when I wore straw sandals. I sent the three boys out daily, hiring as much local help in addition as possible, and had more of the people bring me in specimens of any sort they came across. By taking care of the plant drying myself and preparing labels and other materials I was able to keep the boys out in the field longer, but still my trouble was greatly handicapping.

During this period a Chinese expedition arrived and took up quarters in the other wing of the house. The group, led by Professor W. C. Cheng, codescriber of the *Metasequoia,* included Professor K. L. Chu, plant ecologist from Shanghai, and Mr. C. T. Hwa, who had made the first trip to collect seeds in 1947.

On the twenty-eighth my assistant returned. Again I received no mail, as the letters that had arrived had been forwarded promptly. The next evening, market day, these did arrive, and I had my first mail from home in six and a half weeks. The following morning, still unable to walk, I left in a sedan-chair that was made from bamboo on the spot that morning. Our same porter carried my baggage, including our new collections and more *Metasequoia* seedlings. My sedan-chair was carried by three men: two in front and one behind. It was crudely made, without a backrest, but actually I found it quite convenient, as far as my feet permitted me to be comfortable, since I sat upright on my folded blanket, my feet hanging, and could see in all directions. There was a crude framework for a covering, but as I had nothing to cover it with, I kept my raincoat handy. The framework helped to keep the vines and thorns out of my face, particularly when I might doze. Constant sitting became monotonous, except for the scenery, and I would occasionally doze, even in some of the parts along small precipices. Once I nearly upset the chair. Since we aimed to reach Wan Hsien in four days, and since the going was difficult for the men on steep trails, we had to travel long hours with few rests. The first night, reaching Wang-chia-ying, we had to travel some distance after dark. The second night was spent at the market beyond Mo-tau-chi.

On the afternoon of the third day, just as we were going to cross to the east side of the Mo-tau-chi River after passing through part of a heavy downpour, the boatman yelled alarm and told everyone to quickly climb the bank. He had seen a crest of water coming in on the tributary joining the river 100 yards above just as he was about to pole off. I was a bit skeptical, and thought he should have crossed anyway, which he could have done, but his return might have been another matter. Within six minutes the water level below us rose two feet, and was still rising when we gave up and went back into the village to find an inn. Apparently in the other valley the downpour had been much heavier, as indicated by the color of the sky and the thunder, and we had just experienced the edge of it. The rain resumed and continued all night. The next day the water was not down enough until early afternoon, when we continued only about three miles, to find that the water here was still too swift for the recrossing to the west side. We spent the night in a very crowded inn and in the morning were able to move on. However, we did not reach the southeast bank of the Yangtze until after dark, and so did not arrive in Wan Hsien until the forenoon of the sixth day.

I spent three days waiting for a ship to Hankow, staying at the home of the Reverend and Mrs. J. B. Matson. With the welcome, good food, and comfortable rest, after the long treatment with sulfathiazol, my sores began to heal and the swelling to subside. By the time I left to board the freighter, a former "LST," I could wear a shoe on one foot, and when Hankow was reached three days later, both shoes were worn. After 24 hours in Hankow, the express train of the Canton-Hankow Railroad was boarded, and Canton reached two days later.

Some of my dawn redwoods were promptly taken down to Hong Kong to be planted on the peak under the care of the Hong Kong Forestry Department, since Canton was thought likely to prove too warm a climate for the survival of the trees. Those sent earlier to Canton, however, had already sent out new leaves, so the climatic tolerance appeared actually not to be so restricted. These and other trees brought by our main group, as well as the seeds planted, all grew and were thriving when I left Canton two and one-half years later.

During the three winters that I remained at Canton it was interesting to watch the reaction of the young trees to the much warmer winters than those to which the tree is exposed in its natural habitat. In Canton (latitude 23° 06′ N.), the temperature rarely drops as low as 36°F., and often is 70° or higher during December or early January, though cooler in February and whenever the wind blows down from North China for a period. Instead of shedding the needles in the autumn, the needles browned slowly and partially as the temperature dropped in winter. This happened in an irregular fashion, with apparently different reactions in different seedlings, some becoming brown when others were still almost entirely green. We frequently suspected certain plants were dying, only to be proven wrong later. The needles rarely actually dropped until the coldest winds in February, after which they were very soon replaced by new needles appearing as soon as the temperature began to rise. Actually we had only about five of some thirty seedlings die. The percentage of germination of the seeds planted was rather low.

Some of our group remained at Suisapa for three more weeks and then moved to Wang-chia-ying for five days. En route back to Wan Hsien they stopped one day near the top of the Chi-o Shan (Seven Humps), three days at Mo-tau-chi, and two at Lung-chu-pa for general collecting. They spent a few weeks near Wan Hsien. Then they made a trip all the way back to Suisapa to collect *Metasequoia* seeds and to take more photographs, with a camera I sent by airmail from Canton to Wan Hsien.

They experienced snow while returning over the Chi-o Shan ridge, and returned to Canton in mid-November, after an absence of nearly five months.

Our collecting resulted in the bringing back of tens of thousands of insects in addition to the plants and miscellaneous animals. The collections are at the California Academy of Sciences. As to the scientific results, it will be some time before any conclusions can be drawn as to possible relationships of the insect fauna of the dawn-redwood flora with that of western North America. It may prove more closely related to that of southeastern North America, as is the case with most of the plant genera in common between eastern Asia and North America. In the meantime specimens of different groups must be studied by many specialists. The few groups studied to date have not demonstrated any significant Nearctic relationships. Some of the material has been reported upon in some of the references cited below.

REFERENCES

CHANEY, R. W.

1948. Redwoods around the Pacific basin. *Pacific Discovery*, vol. 1, no. 5, pp. 4–14.

1951. A revision of fossil *Sequoia* and *Taxodium* in western North America based on the recent discovery of *Metasequoia*. *Transactions of the American Philosophical Society*, new series, vol. 40, pt. 3, pp. 171–263, pls. 1–12.

FLORIN, RUDOLF

1952. On *Metasequoia*, living and fossil. *Botaniska Notiser*, häfte 1, pp. 1–30.

GRESSITT, J. L.

1950. The hispine beetles of China (Coleoptera: Chrysomelidae). *Lingnan Science Journal*, vol. 23, pp. 53–142, pls. 4–8.

1951. The longicorn beetles of China. *Longicornia*, vol. 2, pp. 1–667, 22 pls., 1 map. Paul Lechevalier, Paris.

1952. The tortoise beetles of China (Chrysomelidae: Cassidinae). *Proceedings of the California Academy of Sciences*, vol. 27, pp. 433–592, pls. 27–36, 1 text fig., 4 maps.

MERRILL, E. D.

1948. *Metasequoia*, another "living fossil." *Arnoldia*, vol. 8, pp. 1–8, 2 pls., 1 map.

STEBBINS, G. L., JR.,

1948. The chromosomes and relationships of *Metasequoia* and *Sequoia*. *Science*, vol. 108, pp. 95–99.

WYMAN, D.

1951. *Metasequoia* brought up to date. *Arnoldia*, vol. 11, pp. 25–28.

PROCEEDINGS

OF THE

CALIFORNIA ACADEMY OF SCIENCES

FOURTH SERIES

Vol. XXVIII, No. 3 July 15, 1953

SOME NEW AND NOTEWORTHY APHIDAE FROM WESTERN AND SOUTHERN SOUTH AMERICA
(Hemiptera-Homoptera)

BY

E. O. ESSIG

Department of Entomology and Parasitology
University of California, Berkeley

During the months of December, 1950, to and including April, 1951, Dr. A. E. Michelbacher and his wife, Martha, and Dr. E. S. Ross and his wife, Wilda, conducted an intensive insect-collecting expedition in Chile, in particular, and less extensively also in Argentina, Bolivia, and Peru with some minor collecting while en route by boat along the coast of Central America and Colombia. This expedition was a part of the activities of the California Academy of Sciences which institution arranged for the ocean transportation and supplied a truck for travel on land. On October 17, 1950, the party sailed from San Francisco on the Grace Line steamship *Santa Juana*—destination: Valparaiso, Chile. Their ship stopped at various ports on the voyage and small collections were made at Buenaventura, Colombia; Callao, Peru; and other ports. Upon arrival at Valparaiso the party was cordially received by the veteran Chilean entomologist, Dr. Edwyn P. Reed, and by Dr. Raul Cortes of the Chilean Ministry of Agriculture, who rendered the Americans invaluable hospitality, information, and assistance during their stay in Chile.

Although large collections were made of all kinds of insects, of which thousands were taken, Dr. and Mrs. Michelbacher also gave special attention to collecting as many species of aphids as time and opportunity permitted. By much hard work they procured a sizable assemblage of species which were preserved in alcohol and turned over to the writer for mounting and study, and for the publication of desirable information concerning them.

Little previous investigational work has been done on the aphids of Chile, in which country by far the greatest numbers of individuals and species were taken.

To the present time there have been relatively few technical papers on the aphids of western South America. In Chile, where the greater part of the insect collections were made, there has been, so far as I know, only a single new species, *Aphis citricola* van der Goot (1912), described and this has been found to be the already described *Aphis citricidus* Kirkaldy, 1907 (*Myzus*).

In Argentina and Brazil a number of able aphidologists have published many important contributions on the systematics and economics of the Aphidae in those countries as the elaborate bibliography included herein testifies. It is to be expected that interest in this field of entomological endeavor will rapidly expand in the future.

Because of the very convenient method of travel, by means of a specially fitted Ford panel truck, the party penetrated areas rarely visited by foreign insect collectors and most of the specimens were taken in the wilds of the countries traversed. Thus their undivided time and attention were given to their objectives which proved very fruitful in the way of securing splendid insect collections. They remained in Chile from November 25, 1950, until February 4, 1951, when they started on the trip over the Andes via Paso de Bermajo en route to Mendoza, Argentina, and thence eastward and northward through the cities of Rio Cuarto, Cordoba, Tucuman, Salta, Jujuy and La Quiaca, Argentina; through Camargo, Potosi, Oruro, and La Paz, Bolivia; via Lake Titicaca, Puno, Tinta, Abancay, Ayacucho, Huancayo, Oroyo and Lima, Peru. They arrived at Lima, March 4, 1951. During the remainder of their stay they travelled about 550 miles in the coastal area north of Lima through Huacho, Trujillo, Chiclayo, and to a point north of Olmos. Dr. and Mrs. Michelbacher and Mrs. Ross sailed homeward from Lima on the S.S. *Santa Flavia* on April 6 and Dr. Ross followed about a month later.

For collecting Aphidae and other small insects Drs. Michelbacher and Ross had a large supply of small glass vials. Specimens of aphids and often portions of the host plants, and labels bearing the date and locality, as nearly as the latter could be ascertained, were preserved together with each lot. These specimens have since been mounted and determined as to species as far as possible.

In cases where species collected have also been recorded by entomologists in the South American countries visited: Colombia, Peru, Chile, Argentina, and Bolivia—these have been noted in so far as available literature permitted.

I wish to express my thanks and great appreciations to Dr. and Mrs. A. E. Michelbacher, and to Dr. and Mrs. E. S. Ross for the opportunity to mount and study this fine collection of South American aphids. The large series enabled me to prepare an excellent collection of types, paratypes, and other specimens for the department of entomology of the California Academy of Sciences and duplicate specimens for my own collection. I am grateful to Dr. E. L. Kessel for making important suggestions for the preparation of the manuscript and to Dr. Robert C. Miller, director of the Academy, for the publication of this paper, and especially to my wife, Marie, for typing, correcting, and editing it.

I also wish to thank L. A. Bahamondes, Director General de Investigaciones Agricolas, Ministerio de Agricultura y Ganaderia, Republica Argentina, for furnishing many specimens of Aphidae collected in Mendoza Provincia.

The total collections of aphids amounted to 25 genera; 55 species, including 14 new species; and 3,395 specimens mounted on 781 slides.

CLASSIFICATION AND DESCRIPTIONS OF SPECIES

Order **HEMIPTERA**

Suborder **HOMOPTERA**

Superfamily **APHIDOIDEA**

Family **LACHNIDAE**

Subfamily **LACHNINAE** (PTEROCHLORINAE)

Tuberolachnus saligna (Gmelin)

Giant Willow Aphid

(Figure 1)

Aphis saligna Gmelin, 1788; *A. polaris* Curtis, 1828; *A. viminalis* B. d. Fonscolombe, 1840; *Lachnus dentatus* Le Baron, 1872; *L. fuliginosus* Buckton, 1891; *Tuberolachnus viminalis* (B. de Fonscolombe) Mordvilko, 1908; *Pterochlorus saligna* (Gmelin) Theobald, 1929.

This large aphid may be readily recognized by the conspicuous pointed tubercle near the middle dorsum of the abdomen. It is widely distributed throughout the temperate regions wherever species of *Salix* occur and it has long been known as a pest of basket willow (*Salix viminalis*) in Europe. From the records it appears that this species occurs throughout the general habitat of *Salix* spp. ("Sauce") (SALICACEAE). Collections were made as follows:

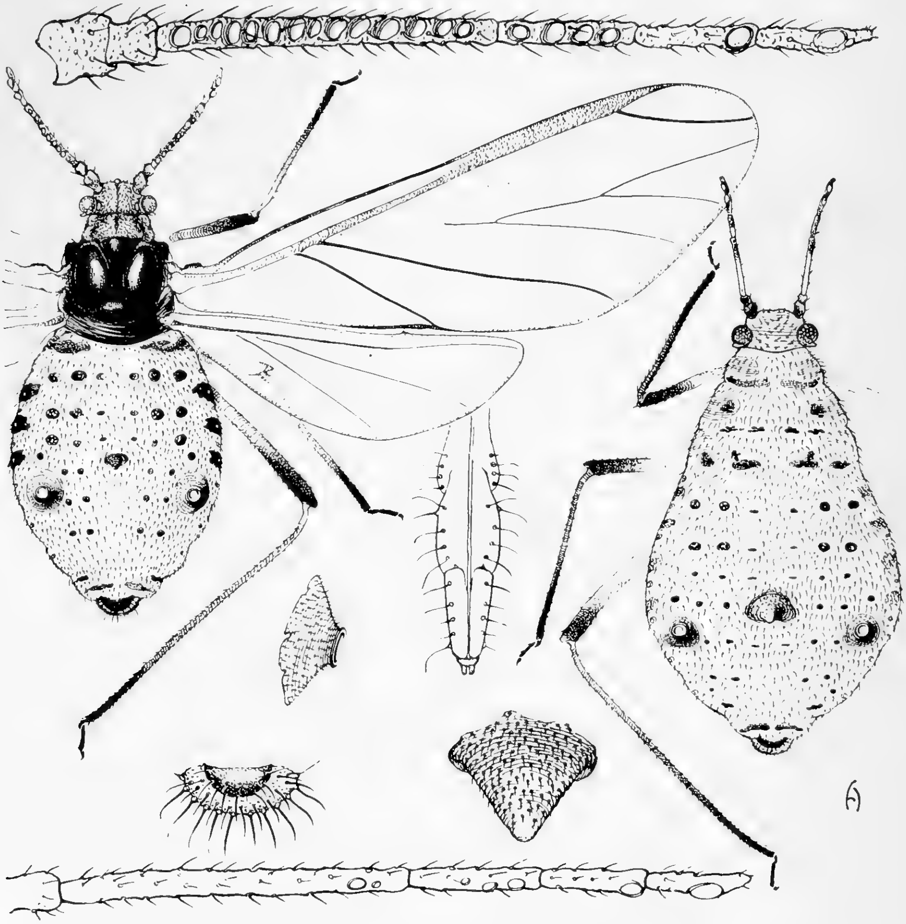


Figure 1. Giant willow aphid, *Tuberolachnus saligna* (Gmelin). Antennal segment III of alate (top) and aptera, tip of rostrum, cornicle, cauda, and anal plate and abdominal tubercle all enlarged.

CHILE:

On *Salix* sp. at Angol, Province of Bio-Bio, January 1, 1951; apterae and alatae.

ARGENTINA:

On *Salix* sp., Uspallata, Province of Mendoza, February 6, 1951. Many specimens of apterae and alatae. Other records by Blanchard 1926, pp. 327–29; 1939, 871–72; 1944, 16) are:

On *Salix* sp., Tigre, Province of Buenos Aires; also from San Juan and Zapala.

On English walnut (nogal or noguera) *Juglans regia* Linnaeus at San Rafael, Province of Tucuman.

PERU:

On *Salix* sp., Barranca, March 15, 1951; all apterae.
All collected by Dr. A. E. Michelbacher.

Family **CHAITOPHORIDAE**

Subfamily **SIPHINAE**

Sipha flava Forbes

Yellow Sugarcane Aphid

This is a subtropical yellowish species occurring on Gramineae in warm, temperate and tropical North and South America. Although not taken by Dr. Michelbacher the species has been reported in two of the South American countries where sugarcane is grown.

ARGENTINA:

Blanchard (1944:17) records this species on sugarcane (caña de azúcar) in Tucuman. The writer has also received a good series from L. A. Bahamondes collected on *Holcus halepensis* (Linnaeus) (*Sorghum* sp.) (sorgo, zahina), at Mendoza, April 9, 1951.

Family **CALLAPHIDAE**

Subfamily **CALLAPIDINAE**

Chileaphis Essig, new genus

(Figure 2)

Alate oviparous female: Head with straight front; antennae 6-segmented; imbricated; hairs few and short; segment III as long as IV and V; unguis very short; primary sensoria circular, rimmed with hairs; secondary sensoria linear or semicircular. Compound eyes well developed and with posterior ocellar tubercles. Wing venation aphis-like with radial sector only slightly curved and free at base. Legs unusual in that the alate oviparous females have numerous sensoria on the tibiae of all three pairs. Cornicles truncate cones and the diameter at the base exceeds the length; with few hairs. Cauda appears like a chitinized lobe which may be recurved. Anal plate with deep median constriction. Ovarian eggs are globular and oval.

In the alate male and apterae the cauda is almost globular with a narrow neck and wide base. Antennae of the male have both transverse and circular secondary sensoria on segments III, IV, V, and VI. Dorsal wax glands are present on all forms. Genotype: *Chileaphis michelbacheri* Essig.

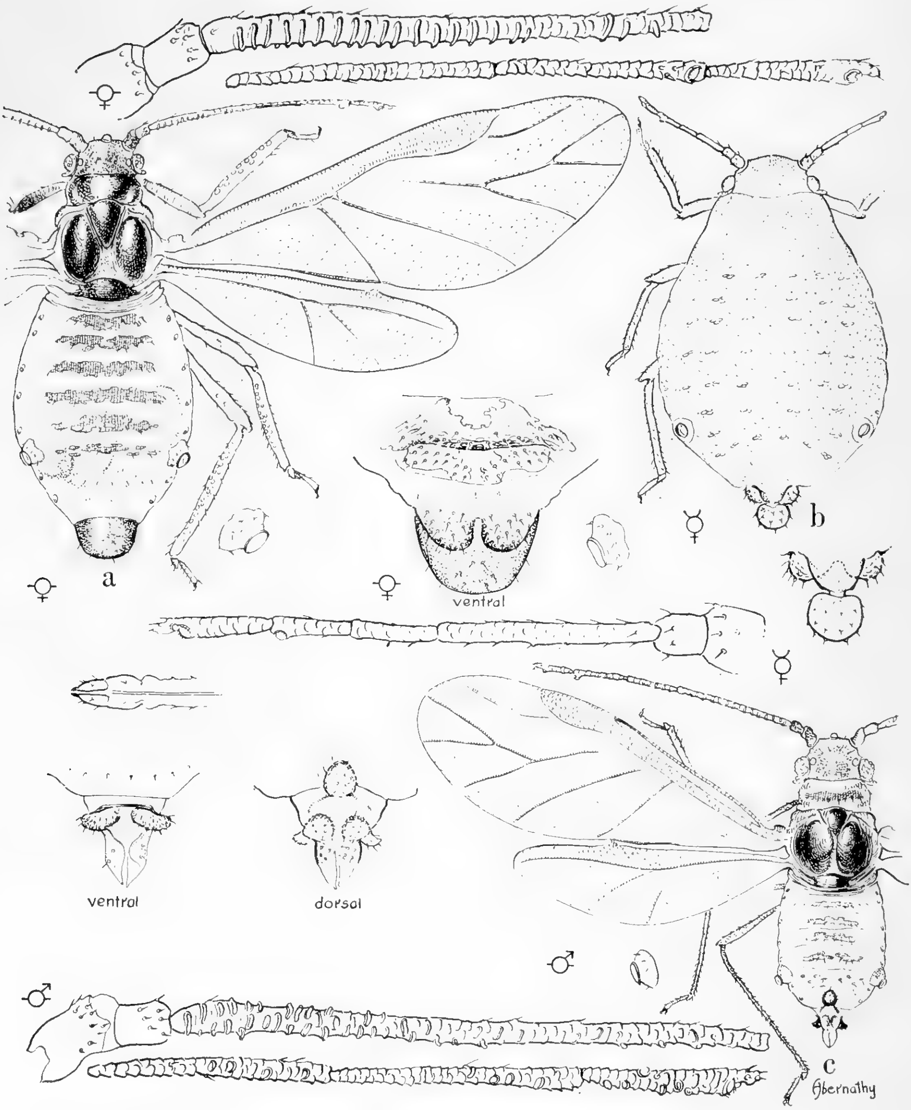


Figure 2. Chilean cypress aphid, *Chileaphis michelbacheri* Essig, new species. a, alate sexual female; b, apterous parthenogenetic female; c alate male. Antennae, cornicles, anal plate and cauda, and male sexual organs.

Chileaphis michelbacheri Essig, new species

Chilean Cypress Aphid

(Figure 2)

TYPE: *Alate oviparous female*: Pale, with the head, thorax, transverse glandular areas on abdomen, cornicles, and cauda, black or dusky. In life the body is probably partially covered with white powdery wax. Antennae imbricated and with few short hairs. Secondary sensoria on segment III linear and a few may be semicircular, scattered over the full length, 25–25 in number. Primary sensoria circular or oval, fringed with short setae. Apical sensoria on VI are compound with at least 2 small marginal ones. Lengths of segments: III, 0.63 mm.; IV, 0.35 mm.; V, 0.25 mm.; VI, 0.21 mm. Rostrum with the apical segments short and blunt; extends to second coxae. Sexual sensoria numerous on the tibiae of all legs. Wings well developed and with aphis-like venation. Radial sector only slightly curved. Second fork of media arises half-way between first fork and wing margin. Abdomen with six distinct pigmented glandular transverse areas. Cornicles dusky, as illustrated; with few short hairs. Cauda unusually large and peculiar, dusky, chitinized and with only a few short hairs. Anal plate bilobed, with many short setae. Genital plate as drawn. Length of body, 2.45 mm.; forewing, 2.8 mm.

Apterous parthenogenetic female: Whitish-gray; in living condition apparently covered with powdery wax; widely oval with short antennae and legs as delineated. Lengths of antennal segments: III, 0.28 mm.; IV, 0.09 mm.; V, 0.10 mm.; VI, 0.12 mm.; unguis nail-like. Cornicles truncate cones, the base about twice the diameter of the opening, with few short scattered hairs. Cauda large, globular, with slender stalk and wide base; with few short hairs. Anal plate deeply cleft into two lobes; with few short hairs.

Alate male: Similar in color and general appearance to the alate female but much smaller, being 1.74 mm. in length. The antennae are as illustrated. The sensoria are numerous, smaller and more oval and linear than those of the alate sexual female and occur on all the segments excepting I and II. The globular cauda is illustrated in the turned-up natural position and the sexual organs and cornicles are as drawn.

Host plant and locality: This interesting new genus and species was collected by Dr. A. E. Michelbacher by beating the available limbs and foliage of the Chilean cypress, *Pilgerodendron uviferum* (Don) Florin. The synonymy of this host plant is given by Record and Hess (1943) as follows: (*Juniperus uvifera* Don = *Thuja tetragona* Hooker—*Libocedrus tetragona* [Hooker] Endl. = *L. cupressoides* Sargent = *L. uvifera* [Don] Pilg.)

Locality: **Los Muermos, Province of Llanquihue, Chile.** It was collected only in this single locality by Dr. Michelbacher for whom the species is named.

The total number of individuals examined consisted of 50 apterous parthenogenetic females, 38 alate oviparous females, 34 immature apterous and alate forms, and 2 alate males, all mounted on 25 slides.

This species differs from other known related species in having sensoria on the tibiae of all legs of the alate oviparous female and the presence of both circular and transverse sensoria on the antennae of the alate male.

Neuquenaphis[1] **michelbacheri** Essig, new species

Nothofagus Aphid

(Figure 3)

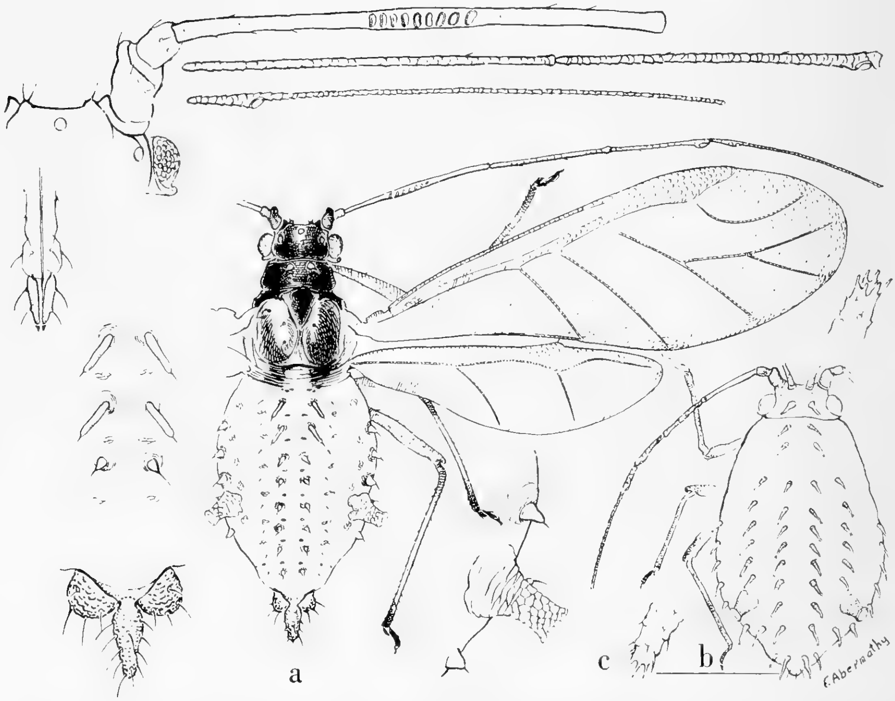


Figure 3. Nothofagus aphid, *Neuquenaphis michelbacheri* Essig, new species. a, alate parthenogenetic female together with head and antenna, rostrum, some tubercles and spines on dorsum of abdominal segments I–II, anal plate and cauda, and cornicle; b, young; c, apex of one of the body tubercles.

---

[1] From the Province of Neuquen, Argentina.

TYPE: *Alate parthenogenetic female*: Color uncertain, the cleared alcoholic specimen indicates that the head, antennal segments I and II, and thorax are black and the legs, cornicles, tubercle bases, cauda, anal plate, and abdominal glandular areas are dusky. It is probable that in life a fine powdery wax may cover portions of the body. The illustration, together with the description of the genus, will give a good idea of the important characteristics. [It is well to point out that the apterous form on the lower right is probably a second or third instar young, but its peculiar tubercles will nevertheless assist in recognizing the genus and species.] Of special interest are the tuberculate first segments of the antennae; the arrangement of the oblong sensoria—11–15 near the middle of segment III; the very long flagellum; the large, distinct tooth-like structure on the inner margin near the apex of the fore femora; the faintly clouded wing veins which do not show in the drawing; the arrangement of the spined body tubercles, as figured; the short reticulated cornicles and the rather unusual type of cauda should make the species easily recognizable. In other alate paratypes the number of sensoria may vary from 8–16.

Host plant and locality: The species was collected by beating the branches of *Nothofagus dombei* Blume. It was collected along with *Spicaphis michelbacheri* and *Neuquenaphis chilensis* on the **Niagara Rancho near Temuco, Province of Cautin, Chile.** Thirteen apterous specimens and 3 alates were also collected in San Andres, Paranque, Chile. Collector, A. E. Michelbacher.

The specimen described was selected from 16 adult alate parthenogentic females and has been designated as the type; all others as paratypes. There were also 3 immature specimens in the lot. They were mounted on 13 slides.

Neuquenaphis michelbacheri differs from *N. edwardsi* (Laing) (*Myzocallis*) in the following respects:

1. Head and thorax much narrower.
2. Presence of small setae-bearing tubercles on the pronotum.
3. Much shorter tubercles on dorsum of abdominal segments I and IX.
4. The presence of a prominent tuberculate seta or spine on the outer surface of the cornicle.
5. Somewhat more elongated cauda.

Neuquenaphis chilensis Essig, new species

Dombei Aphid

(Figure 4)

TYPE: *Alate parthenogenetic female*: Color uncertain because speci-

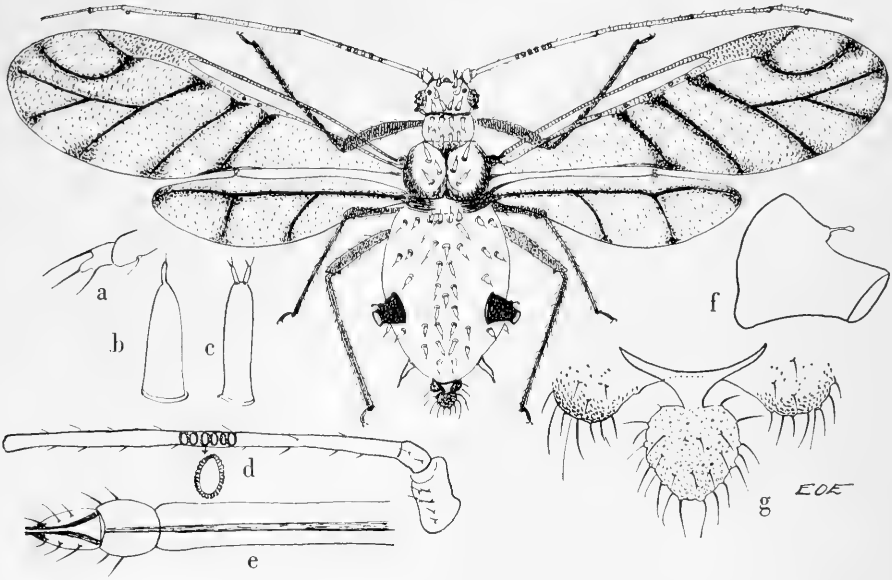


Figure 4. Dombei aphid, *Neuquenaphis chilensis* Essig, new species. a, tip of antenna; b, body tubercle; c, frontal tubercles; d, antenna showing secondary sensoria; c, rostrum; f, cornicle; g, cauda and anal lobes.

mens were preserved in alcohol and may have faded somewhat. Mounted ones are brownish and black and quite similar to the alates of *Neuquenaphis michelbacheri*. All of the body, excepting the abdomen, is dusky or brown. The cornicles, anal plate, cauda, and body tubercles are also brown. The most outstanding characteristic of the species is the large number of blunt, fleshy, cylindrical tubercles each of which is terminated with one or two short, slender setae. They vary considerably in size and are arranged somewhat as illustrated. The antennae are long and slender—extending almost to the tips of the wings; imbricated; 6-segmented; III much longer than either IV or V, but not as long as both together; IV is longer than V; the unguis of VI is 1¼ times the length of the base. Segments III have 6–6 large elongate sensoria which extend to the full width and are located near the middle. (In three paratypes the ratio is 5–5, 6–6 and 6–7.) The rostrum is fairly broad and extends to the second coxae. The legs are sparsely clothed with short, fine hairs. The wings are aphis-like and the veins are cloudy. The abdomen is beset with numerous tubercles which are variable in size and with small grouped dark wax glands; also there are five bands of small setae. The cornicles are short and somewhat truncate, with a single lateral marginal spine and somewhat imbricated; the base is twice the diameter of the apex. The cauda is conspicuous; knobbed, being widest at the base, thickly beset with small pimple-like areas and large recurved spines supported by raised conical bases. The anal plate is shallow-divided; the two lobes are spined much like the cauda. Length of body 2.20; forewing 2.60 mm.; antennae 1.30 mm.; cornicle 0.10 mm.; cauda 0.15 mm.

This species differs from *Neuquenaphis michelbacheri* and *N. edwardsi* in having tubercles on the head and thorax; capitate cauda; very much shorter antennal unguis; and fewer antennal sensoria.

Host plant and locality: This species was collected along with the *N. michelbacheri* by beating the branches of *Nothofagus dombei* at **Hacienda San Andres,** near Purranque, **Province of Osorno, Chile,** January 15, 1951, by Dr. A. E. Michelbacher.

The type was selected from three alate specimens, all that were collected.

Subfamily **SPICAPHINA**

Spicaphis Essig, new genus

(Figure 5)

Apterous viviparous female: Robust, the dorsum of the entire body beset with thick, rugose, glandular-like spicules or tubercules arranged for the most part in longitudinal and transverse rows; each spicule has a terminal glandular spine or seta. Similar spines also occur on the head, two basal antennal segments and cornicles. Antennae 6-segmented; eyes compound with terate tubercles. Cornicles cone-shaped and with a single tuberculate spine. Cauda knobbed. Anal plate with shallow median constriction. Genotype: *Spicaphis michelbacheri* Essig.

Spicaphis michelbacheri Essig, new species

Michelbacher Aphid

(Figure 5)

Type: *Apterous female*: Alcoholic specimens grayish with pigmented areas as shown in the illustration. The most important feature is the presence of numerous stout, somewhat curved, rugose tubercles arranged in what appears to be a definite pattern on the dorsum. Each of these terminates in a glandular seta. There are approximately 100 of these present. Between the body segments there are a series of small black glandular (?) areas. On the front of the head there are a pair of rather blunt tubercles, each bearing two glandular setae. The antennae are 6-segmented; the two basal segments with glandular setae and a few short spines on the other segments. The permanent sensoria are circular, fringed, and the apical

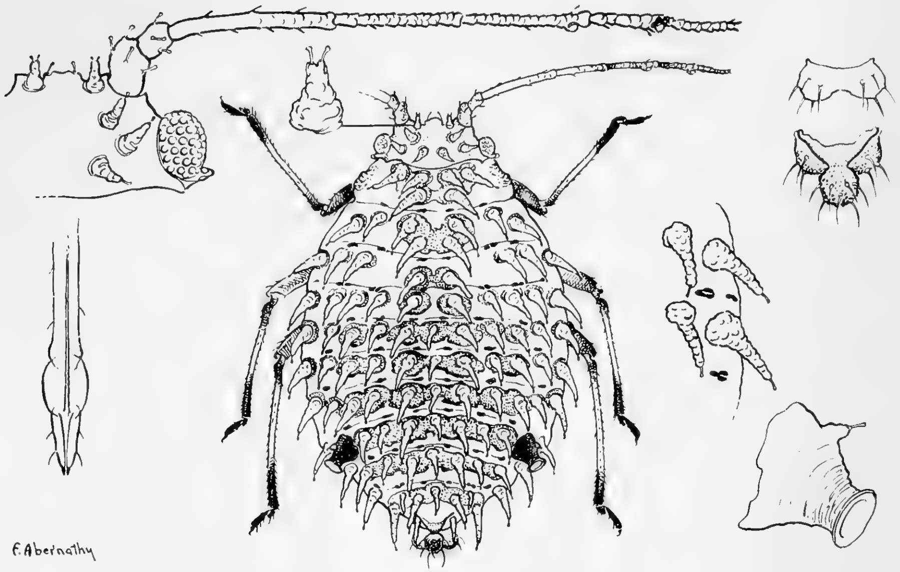


Figure 5. Michelbacher aphid, *Spicaphis michelbacheri* Essig, new species. Apterous parthenogenetic female with enlargements of head and antenna, rostrum, head tubercle, anal plate and cauda, body tubercles, and cornicle.

one on segment V is compound. Segment III is longest; IV, V and VI are subequal; the base and unguis of VI are also equal in length. The eyes are compound with well-developed terate tubercles. The legs are relatively short with very short hairs. The rostrum extends to the third coxae. The cornicles, cauda, and anal plate are as illustrated. Length of body, 1.92 mm.; antennae 1.26 mm.

Described from a single apterous specimen which is designated as the type.

Host plant and locality: The specimen was obtained by beating the limbs and foliage of *Nothofagus dombei* Blume, a tree native to southern Chile. It was taken along with *Neuquenaphis michelbacheri* described elsewhere. The collection was made at **Los Muermos in the Province of Llanquihue, Chile,** on January 15, 1951, by Dr. A. E. Michelbacher for whom the species is named.

Type: A single apterous female so designated.

It is barely possible that this may prove to be the apterous form of *Neuquenaphis chilensis;* the chief similarities being in the antennae, cornicles, and cauda. It differs in having a much wider body and more numerous body tubercles. The true apterous forms of *N. chilensis* are unknown.

Family **APHIDAE**

Subfamily **APHIDINAE**

Tribe **Rhopalosiphonini**

Hyalopterus arundinis (Fabricius)

Mealy Plum Aphid

(Figure 6)

Aphis pruni Geoffroy, 1762; *A. arundinis* Fabricius, 1775; *Hyalopterus pruni*, Koch, 1854.

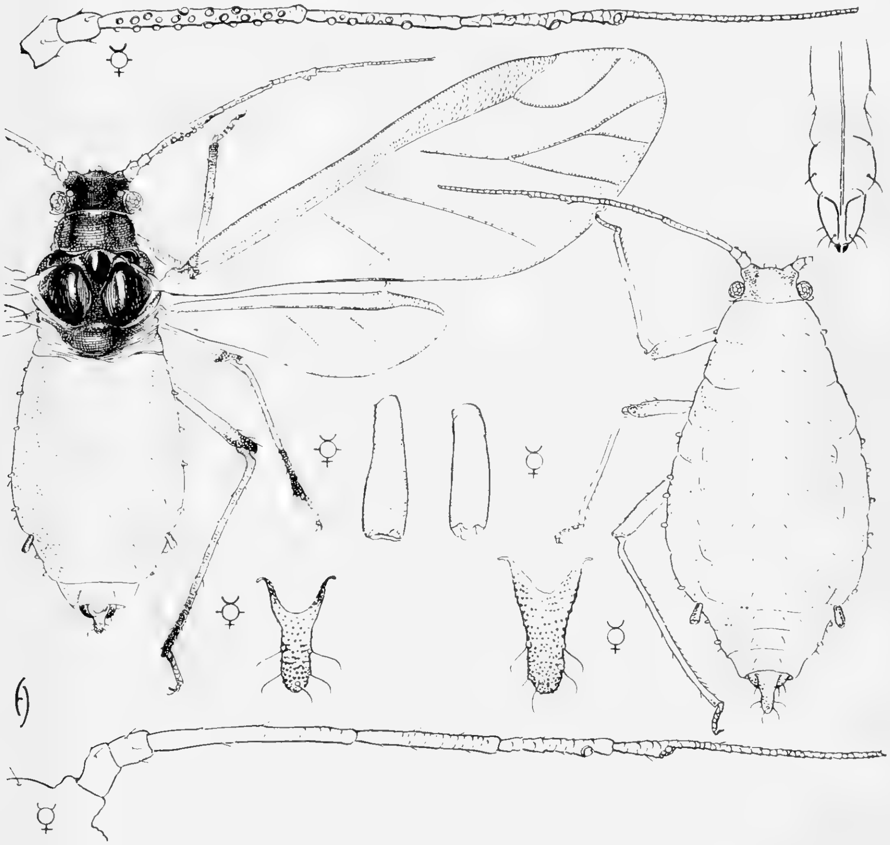


Figure 6. Mealy plum aphid, *Hyalopterus arundinis* (Fabricius). Alate and apterous females with enlarged antennae, rostrum, cornicles, and caudas.

This aphid is very common and often injurious to prune trees in CHILE according to the observations of Dr. Michelbacher, who, because of its abundance, did not make any collections of it.

It has been reported in Europe, Asia, Africa, Australia, North America, and now in South America. It overwinters in the egg stage on plums.

prunes, apricots, apples, peaches, and related plants, and usually spends the summer on reed grass, *Phragmites phragmites* (L.) and cat-tail (*Typha* spp.). The eggs are laid on trees of the genus *Prunus* and the spring generations occur on them. It is often injurious to the hosts and excretes quantities of honeydew over fruit and foliage.

Rhopalosiphum[2] **maidis** (Fitch)

Corn Leaf Aphid

(Figure 7)

Aphis maidis (Fitch) 1856.

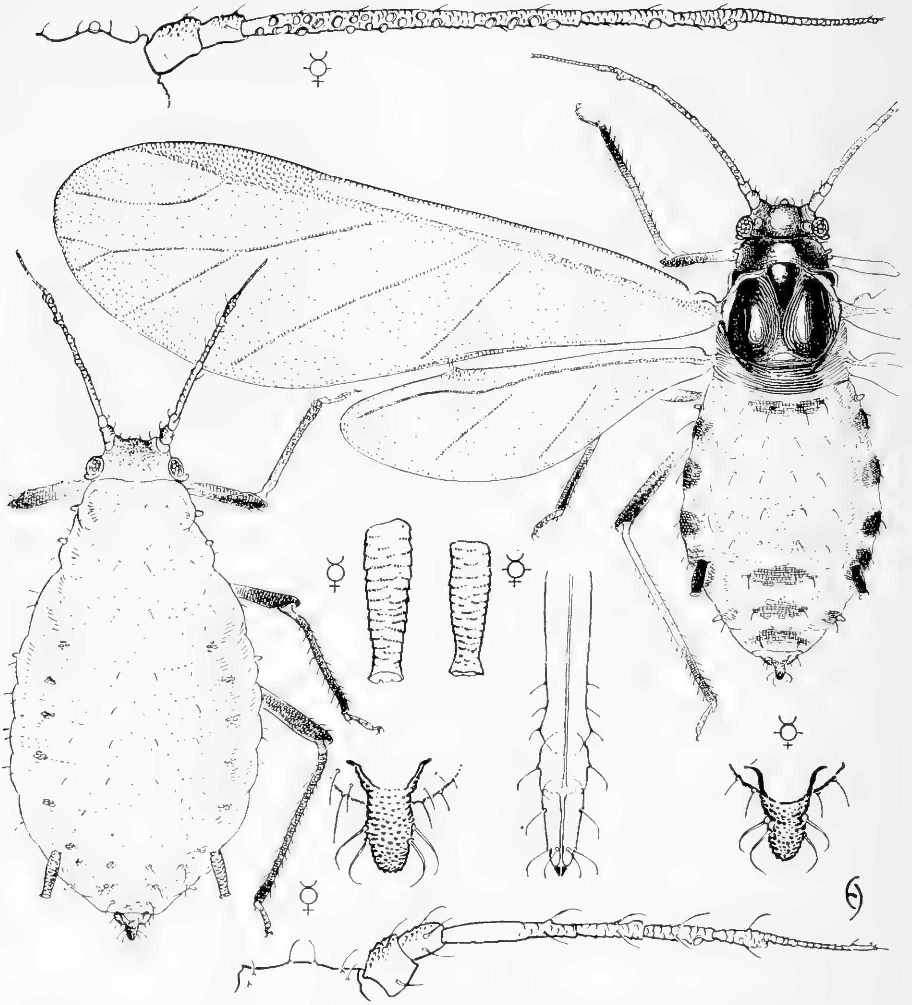


Figure 7. Corn-leaf aphid, *Rhopalosiphum maidis* (Fitch). Alate and apterous parthenogenetic females with enlarged antennae, cornicles, and caudas.

---

[2] The ending "on" is the correct form for the Latin *siphon*.

This aphid is widely distributed throughout North and South America and in many of the South Pacific Islands. It is frequently associated with cultivated corn but also feeds on sedges (*Carex* spp.) and *Scirpus* spp., *Typha* spp., many grasses, *Zea mays* L., and other plants. Collections were made as follows:

PERU:

On Johnson grass, *Sorghum halepense*, Callao, November 14, 1950—very abundant.

On cultivated corn (maiz), Callao, November 17, 1950—1 alate and 5 apterae.

On cultivated corn, Cusco, Province of Cusco, March 4, 1951—many apterae and alatae.

On cultivated corn, Chiclayo, Province of Lima, March 21, 1951, apterae only.

ARGENTINA:

On corn, *Zea Mays* L., *Avena* spp., *Hordeum* sp., *Saccharum* spp.

In Argentina it is a vector of the mosaic of sugarcane according to Blanchard (1939:907–98; 1944:19).

Rhopalosiphum nymphaeae (Linnaeus)

Waterlily Aphid

(Figure 8)

Aphis nymphaeae LINNAEUS, 1761.

This is a Holarctic species widely distributed in Europe and North America. It overwinters on members of the genus *Prunus* and spends the summer on many aquatic and other host plants. It was collected only once.

PERU:

On *Canna* sp. in the Botanical Gardens, Lima, November 15, 1950—many alatae.

Rhopalosiphum prunifoliae (Fitch)

Apple-Grain Aphid

(Figures 9–10)

Aphis prunifoliae FITCH, 1855; *Rhopalosiphum pseudoavenae* PATCH, 1917.

This aphid is a widely distributed economic species in North America

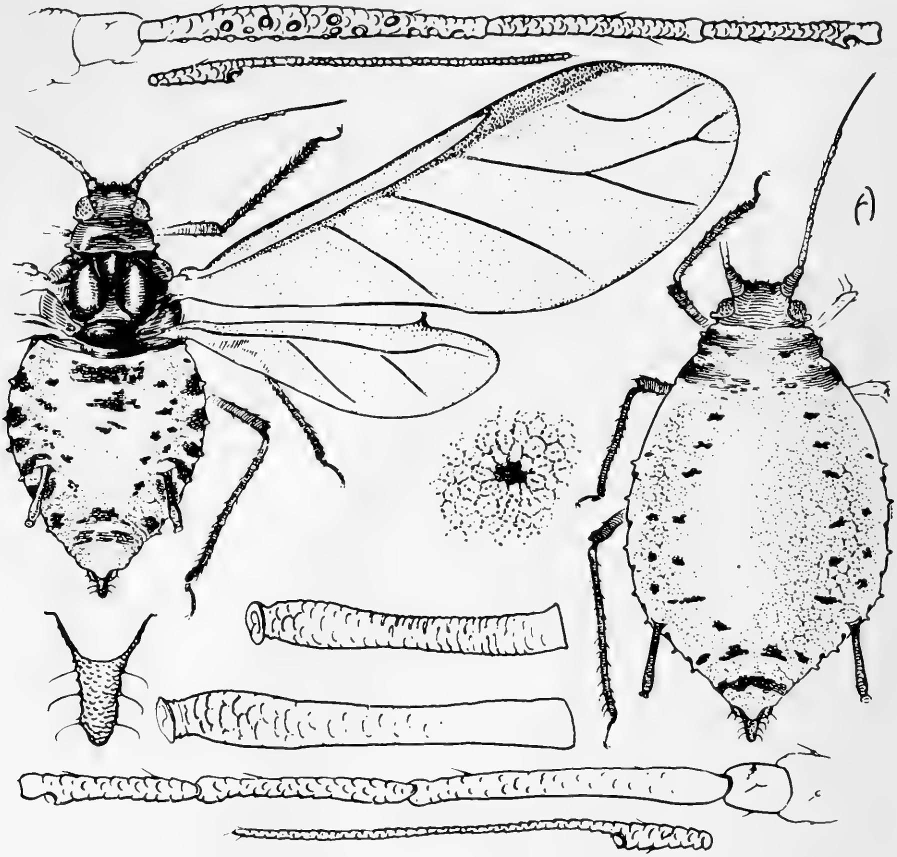


Figure 8. Waterlily aphid, *Rhopalosiphum nymphaeae* (Linn.). Alate and apterous parthenogenetic females with enlarged antennae, cornicles, cauda, and reticulated area on the dorsum of the aptera. (After Zimmerman, 1948.)

where it infests grains, corn, and grasses. In the colder areas it may overwinter on apple and other deciduous fruit trees.

Chile:

Sweeping, Los Muermos, Province of Llanquihue, January 20, 1951—3 alates.

Peru:

Beating plants at Andahuaylas, Province of Apurimac, February 7, 1951—1 alate.

On cultivated corn, *Zea mays* L., Cusco, March 4, 1951—apterae only.

It is a serious pest of sweet corn in California.

Figure 9. Apple-grain aphid, *Rhopalosiphum prunifoliae* (Fitch). Colonies on an ear of corn. (Photo by Oscar Bacon, August 31, 1951.)

Argentina:

It is possible that some of the records of *Rhopalosiphum pseudoavenæ* (Patch) on rye (centeno), maize (maiz), wheat (trigo), and *Bromus* sp., in Argentina, may refer to this species. Blanchard, 1939:908–911; 1944:19).

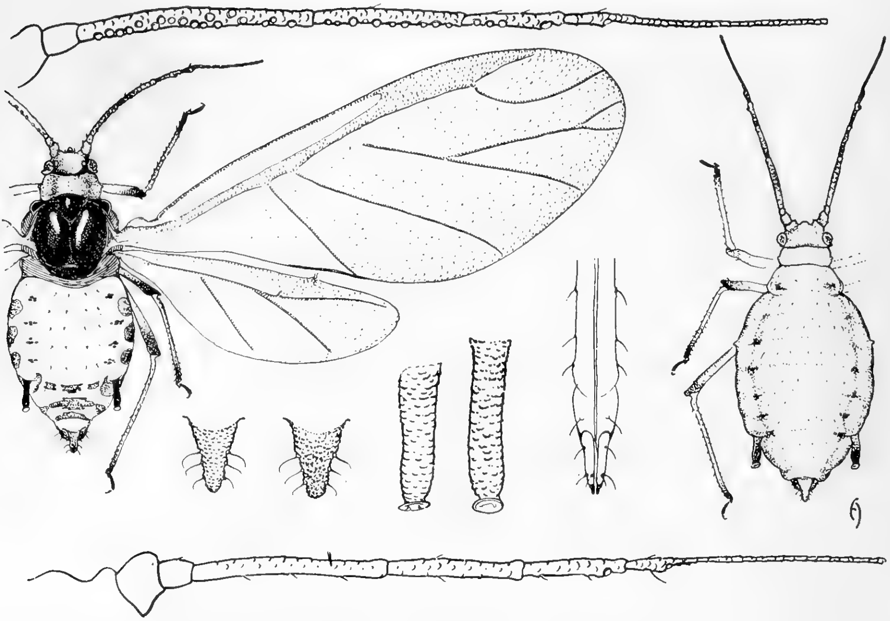


Figure 10. Apple-grain aphid, *Rhopalosiphum prunifoliae* (Fitch). Alate and apterous parthenogenetic females and enlarged antennae, caudas, cornicles, and rostrum.

Rhopalosiphum pseudobrassicae (Davis)

Turnip Aphid

(Figure 11)

Aphis pseudobrassicae DAVIS, 1916.

This may be an Asiatic species which has been widely distributed by commerce. The writer has specimens from China (Nanking, Pehpei, Hangchow), Territory of Hawaii, Iraq, Egypt, Uganda, and North America.

BOLIVIA:

On a native *Nasturtium* sp. growing in a garden at Potosi, Province of Potosi, February 22, 1951—many apterae and 1 alate.

ARGENTINA:

On *Brassica nigra* Koch and *B. rapa* L. in the Province of Buenos Aires. (Blanchard, 1939.)

On *Lepidium* sp., (alheli), stocks of gilliflower *(Mathiola hederacea)* and (rabanito) or radish (*Raphanus sativus* L.).

Peru:

On cultivated stocks, *Methiola* sp., at Callao, Province of Lima, November 4, 1950—many apterae and alatae.

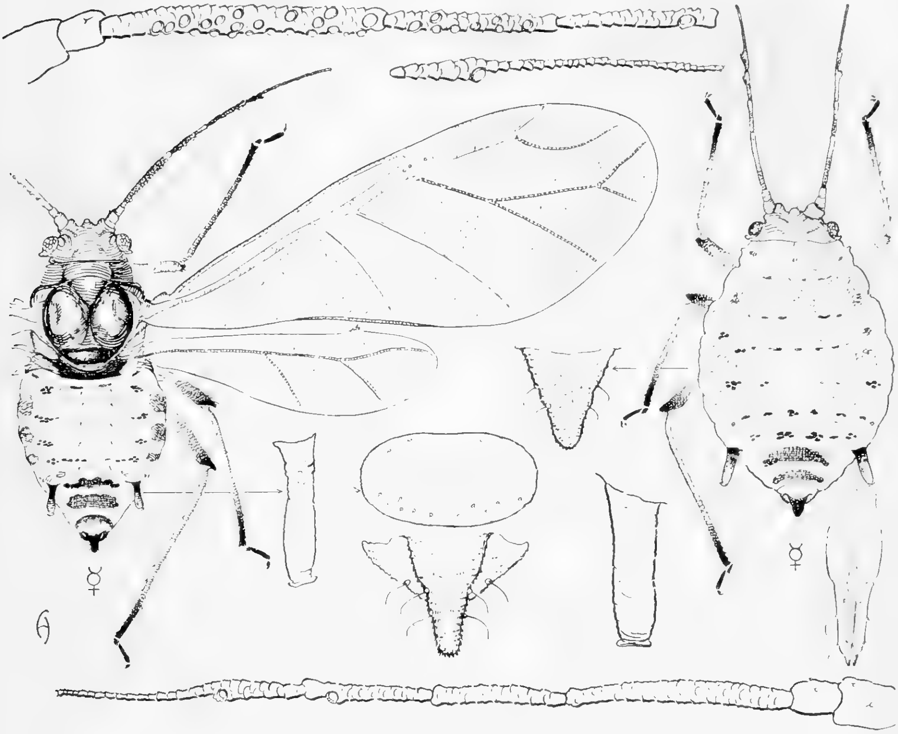


Figure 11. Turnip aphid, *Rhopalosiphum pseudobrassicae* (Davis). Alate and apterous parthenogenetic females with enlarged antennae, cornicles, genital plate, anal plate and cauda, and rostrum.

Rhopalosiphum splendens (Theobald)

Subterranean Aphid

(Figure 12)

Siphonocoryne splendens Theobald, 1914; *Rhopalosiphum subterraneum* Mason, 1937.

This aphid is chiefly a root-infesting species occurring in many parts of North America, in Hawaii, in Africa, and now collected for the first time in South America, and so far only in Peru.

Peru:

Feeding on roots of grasses (?) under stones in the bed of the Red

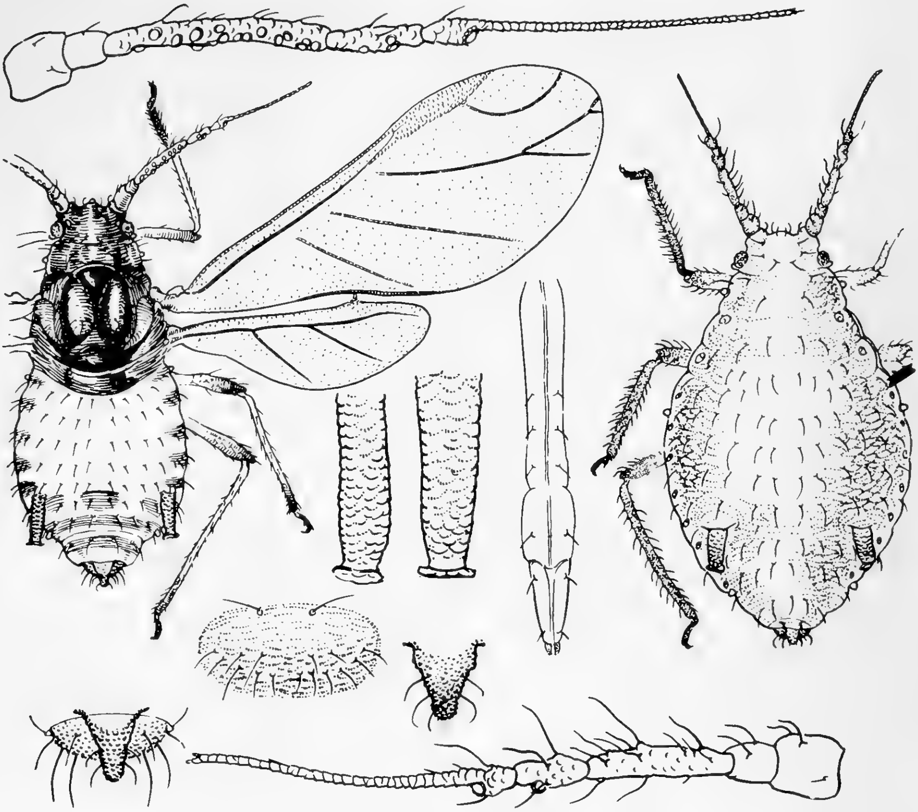


Figure 12. Subterranean aphid, *Rhopalosiphum splendens* (Theobald). Alate and apterous parthenogenetic females with enlarged antennae, cornicles, rostrum, genital and anal plate, and caudas.

River, Callao, November 16, 1950—8 alatae and 3 apterae. Collected by Dr. E. S. Ross.

Beating nightshade (*Solanum* sp.) at Andahuaylas, Province of Apurinac, February 7, 1951—a single alate specimen.

Tribe **Aphidini**

Aphis alstroemeriae Essig, new species

Alstroemeria Aphid

(Figure 13)

TYPE: *Alate parthenogenetic female*: Mostly black; the abdomen paler with black setal patches and areas around spiracles and two transverse bands posterior to the cornicles. Antennae with short spines and sen-

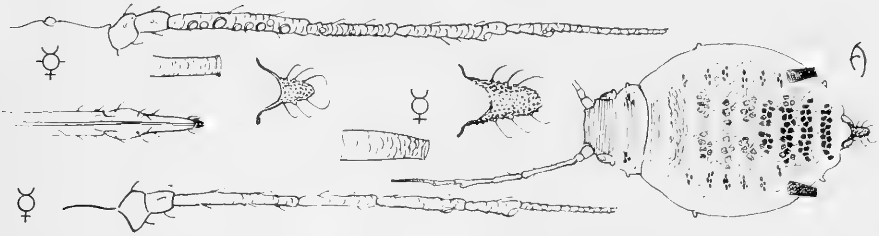


Figure 13. Alstroemeria aphid, *Aphis alstroemeriae* Essig, new species. Antenna of alate; rostrum; cornicles and caudas of alate and aptera; aptera showing dorsal reticulated pattern.

soria as drawn; unguis nearly three times the length of the base; circular secondary sensoria on segment III of different sizes; 9 to 11 in number; IV with 0 to 2. (In paratypes the variation is III, 5 to 11; IV, 0 to 2.) Rostrum slender and short, extending to the third coxae. Prothoracic tubercle present. Wings normal, second fork of media arises near the middle of the distance from first fork to margin of wings. Legs with scattered spines the length of which is less than the diameter of the tibiae; hind tibiae darker at apices; tarsi noticeably long. Cornicles nearly cylindrical, being broader at base, imbricated, and with slightly flanged opening. Anal plate rounded, spiculate, and spined. Cauda with wide base, the apical portion almost parallel-sided. Length of body 1.75 mm.; hind tibiae 0.10 mm.; cornicle 0.17 mm.; cauda 0.14 mm.; antennae 1.29 mm.

Apterous parthenogenetic female: Robust in form and generally dark in color. The dorsum has a mosaic pattern of lines and dark and lighter usually 5-sided tile-like areas which are most pronounced on the dorsum, especially posteriorly. Antennae dark excepting III, IV and base of V. Legs dusky or black with the basal three fourths paler. Rostrum, cornicles, cauda and anal plate black. Lateral tubercles present on some of the abdominal segments. Length 1.57 mm.; hind tibiae 0.91 mm.; cauda 0.17 mm.; antennae 1.55 mm.

Number of specimens: The series consists of 34 mature apterous and 23 alate females. A single alate specimen on a slide with 3 other alates and 6 apterae has been designated as the type.

Host plant and locality: The specimens were collected on a native species of the so-called Chilean lily, *Alstrœmeria* sp., **40 kilometers east of Los Andes, Province of Aconcagua, Chile,** February 4, 1951, by Dr. A. E. Michelbacher.

This species differs from *Aphis medicaginis* (Koch) in having secondary sensoria on antennal segment IV and from *A. rumicis* Linn. in having fewer hairs on the cauda.

Aphis citricidus (Kirkaldy)

Tropical Citrus Aphid

(Figure 14)

Myzus citricidus Kirkaldy, 1907; *Aphis tavaresi* Del Guercio, 1908; *Aphis citricola* Van der Goot, 1912.

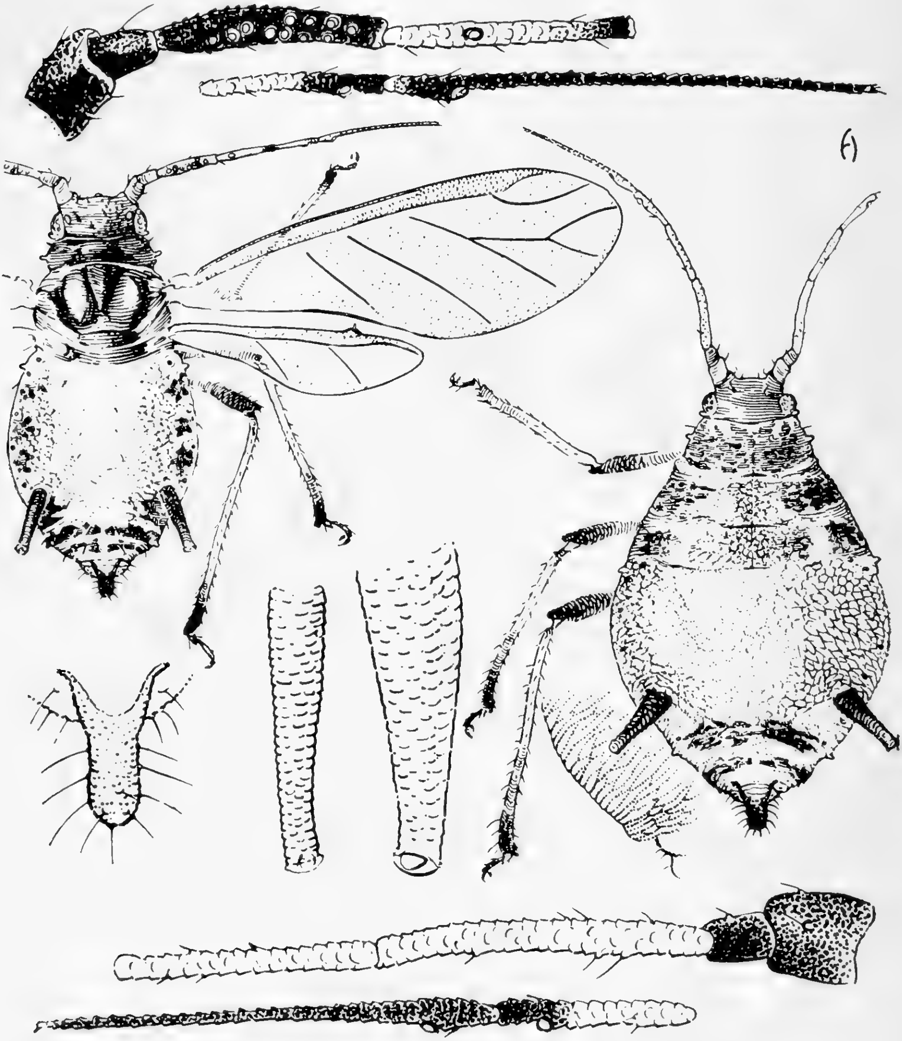


Figure 14. Tropical citrus aphid, *Aphis citricidus* (Kirkaldy).

This is a medium-sized black aphid which is often very abundant on and injurious to the tender apical shoots of its many host plants. It chiefly occurs in the tropical and warm-temperate regions where it feeds mostly upon *Camellia*, *Citrus*, *Hibiscus*, *Mangifera*, and other plants in the more tropical areas of Japan, China, Pacific Islands, Australia, Africa, Southern Brazil, and Argentina, and in greenhouses throughout the world.

CHILE:

In Chile it was first reported and described as *Aphis citricola* by P. Van der Goot in 1912. Locality and host plant were not given.

ARGENTINA:

On *Citrus* spp., at Jujuy, Province of Jujuy, February 15, 1951, by Dr. A. E. Michelbacher. It was abundant on the foliage. Three apterae and 3 alates were taken.

It appears to the author that Blanchard's *Paratoxoptera argentinensis*, collected in orange groves or "naranjales en la Republica Argentina en Santa Ana, Missiones y en Yapeyu, Corrientes," is the tropical citrus aphid as designated above. (Blanchard 1944, pp. 20–22, fig. 1.)

The writer recently received specimens from L. A. Bahamondes collected on *Salix babylonica* L., Guaymallen, Province of Mendoza, November 28, 1950; 8 apterae.

PERU:

On *Citrus* spp. at Chicla, Province of Lima, March 21, 1951; 5 apterae.

Aphis coreopsidis Thomas

Coreopsis Aphid

(Figure 15)

Alate parthenogenetic female: A small species with black head, thorax, antennae, most of the legs, and cornicles; abdomen and cauda pale. Antennae relatively short, with few short hairs; roughly imbricated. Segments III and IV somewhat swollen, III with 8 to 10 large circular and oval secondary sensoria; IV with 4 to 7 and V with 1 to 3 similar sensoria. Rostrum extending nearly to third coxae. Wing veins slightly dusky; two hamuli on each hind wing. Cauda pale with 5 or 6 hairs. Length of body 1.60 mm.; antennae 1.50 mm.; forewings 2.20 mm.; cornicles 0.25 mm.; cauda 0.15 mm.

Apterous parthenogenetic female: Cleared specimens almost entirely pale with apical two thirds of antennal segment III, all of segments IV–VI, and the cornicles black; body with dark areas around spiracular openings. Antennal segment III without secondary sensoria. Rostrum slender, extending to second coxae; with few hairs. Cornicles imbricated, somewhat

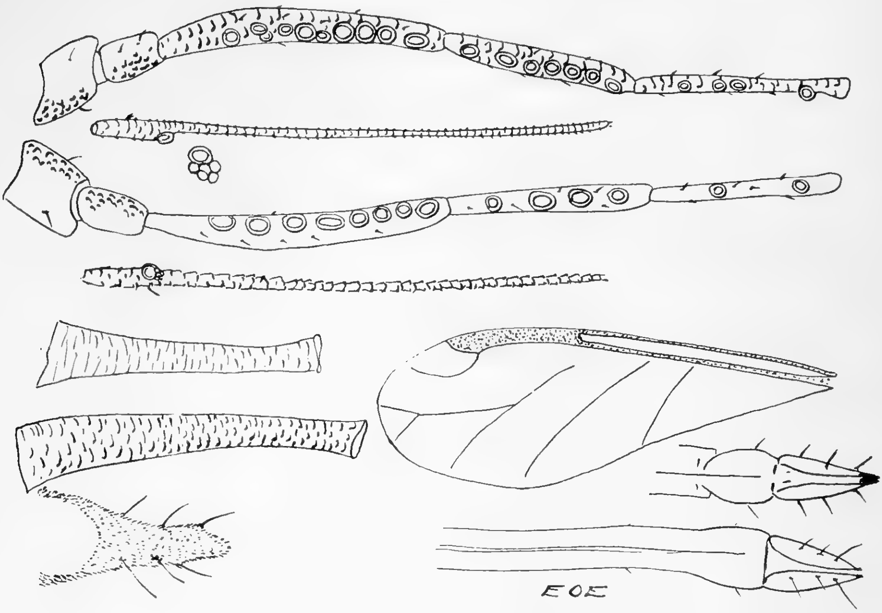


Figure 15. Coreopsis aphid, *Aphis coreopsidis* Thomas. Alate female showing antennae; cornicles, cauda, wing, and rostrum.

curved outwardly; cauda rather thick and with 5 or 6 hairs. Length of body 1.60 mm.; antennae 1.60 mm.; cornicles 0.60 mm.; cauda 0.30 mm.

Colombia:

On a flower of the family Compositae, Buenaventura, November 4, 1950. A single alate, one mature apterous female and two immature specimens were taken. They are mounted on a single slide.

Argentina:

Blanchard (1939, pp. 911, 912–914, fig. 13), reports this species on *Bidens megapotamica* (Speng.) at Missiones, in 1937.

This aphid was described by Cyrus Thomas in 1878 and has been reported on a number of Compositae in many parts of the United States from Connecticut to California.

Aphis gossypii (Glover) 1855 (1854)

Cotton Aphid

(Figures 16–17)

This is a widely distributed species, especially in the warmer temperate and tropical regions. It is probably the commonest species in the

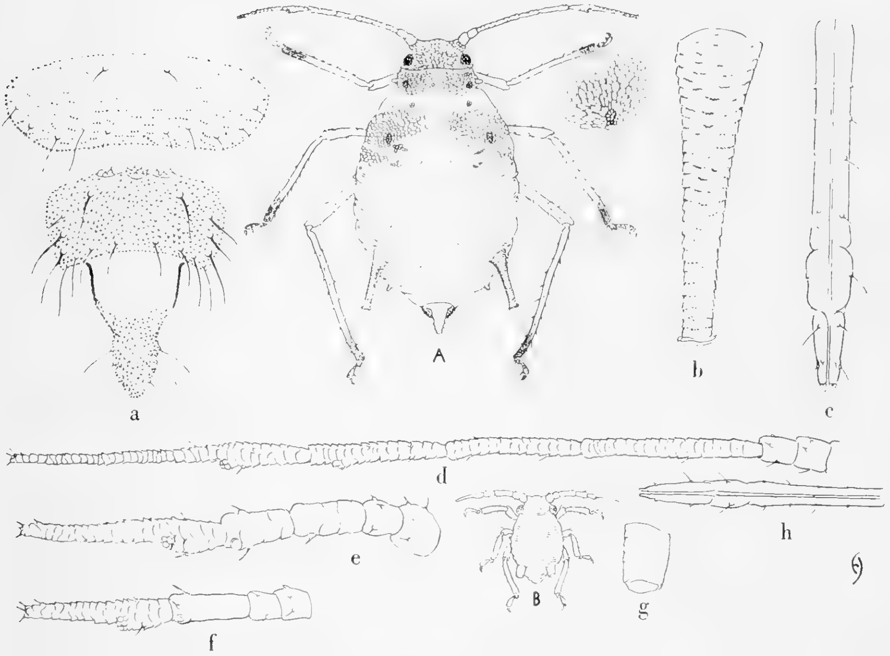


Figure 16. Cotton aphid, *Aphis gossypii* Glover. A, apterous female; a, anal plate and cauda; b, cornicle; c, rostrum; d, antenna; B, first instar young; e, antenna of second instar; f, antenna of first instar; g, cornicle, h, rostrum.

Pacific tropical islands. It also occurs out of doors and in greenhouses in the temperate areas. It is well represented in South America as indicated by the reports of the entomologists of that continent. It was collected as follows:

CHILE:

On squash, calabaza *(Cucurbita maxima)*, Botanical Garden, Lima, November 14, 1950. Alatae and apterae.

On *Bignonia sp.* (?) at Anthofagasta, November 21, 1950. Many apterae.

On *Jacaranda* sp. at Ovalle, Province of Coquimbo, December 1, 1950. A few specimens.

ARGENTINA:

On myrtle-like tree, elevation 4,000 feet, Tucuman, Province of Tucuman, February 11, 1951. Many specimens—apterae and alatae.

On thorny tree, Jujuy, Province of Jujuy, February 15, 1951. A few specimens of apterae and alatae.

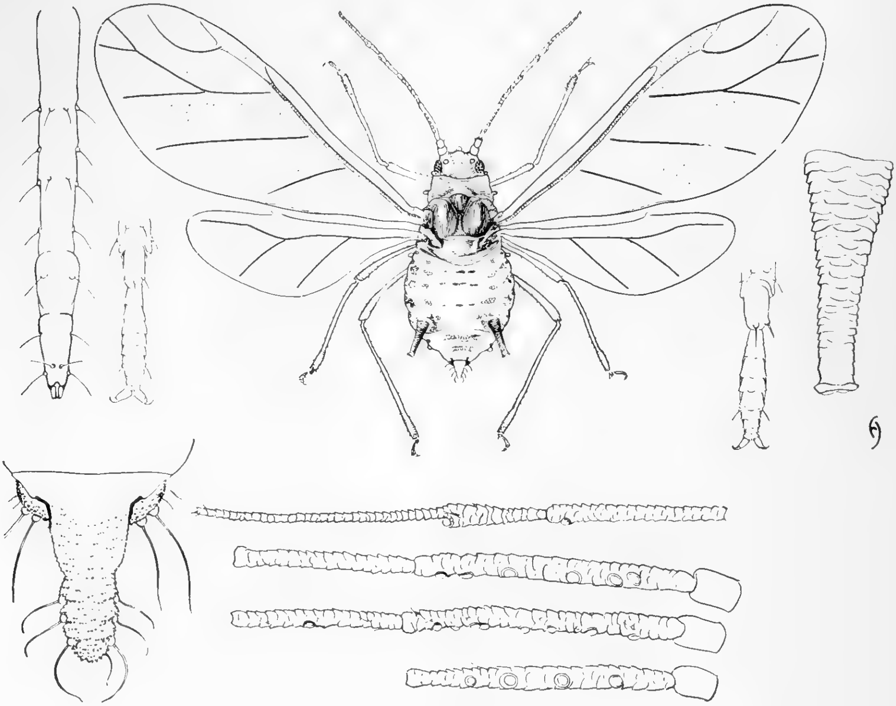


Figure 17. Cotton aphid, *Aphis gossypii* Glover. Alate female and rostrum, tarsi, cornicle, cauda, antennae, cauda.

On *Asclepias* sp., Jujuy, Province of Jujuy, February 16, 1951. Many specimens of apterae and alatae.

E. E. Blanchard (1944, p. 23; 1939, pp. 917–918) lists this species on alfalfa, *Chenopodium* sp., *Jacaranda ovalifolia* R. Br., *Guava* (guaya), *Lilium* sp., (azucena), *Lepidium* sp., *Hibiscus* sp., *Solanum sisymbriifolium* Lam., *Begonia* sp., *Citrullus vulgaris* Schrad., *Cycloma* spp., *Dyckia floribunda* Girs., *Lavatera arborea*, *Mandevillea suaveolens* Lindl., *Morrenia odorata* (Hook et Arn.), *Oleaceae*, *Orthostemon sellowianus* Berg., *Persea americana* Mill., *Pyrus malus* L., *Sechium edule* Sw., *Solanum lycopersicum* L., *Vernonia* sp., *Vitis vinifera* L., and *Zea mays* L.

The writer has recently received specimens from L. A. Bahamondes as follows:

On senna (sen-sen), *Cassia aphila*, Mendoza Capital, October 25, 1948—many specimens.

On pear (pera), *Pyrus communis* L., Mendoza Capital, October 15, 1948—many specimens.

On *Crataegus* sp., Mendoza Capital, December 12, 1950—many specimens.

On *Parthenium hysterophorus,* Mendoza Capital, October 16, 1950—many apterae and alatae.

Colombia:

On *Atriplex* sp. (?), Buenaventura, November 4, 1950. Many alatae and apterae.

On *Baccharis* sp. (?), November 4, 1950—a few alatae and apterae.

On *Compositæ* (?), November 4, 1950—1 alate and 3 apterae.

On a shrub, November 4, 1950—many apterae and a few alatae.

Peru:

On *Casuarina* in Botanical Garden, Lima, November 14, 1950—many apterae and alatae.

On Pomegranate, *Punica granatum* L., Callou, November 14, 1950—a few aptera.

On squash, *Cucurbita maxima* L., Botanical Garden, Lima, November 14, 1950—9 apterae and 6 alatae.

On cultivated potato, *Solanum tuberosum* L., Sicuani, Province of Cusco, March 2, 1951—1 specimen.

On cultivated cotton, *Gossypium* sp., Chanca, Province of Lima, March 15, 1951—4 apterae.

Aphis illinoisensis Shimer

Grapevine Aphid

(Figure 18)

Aphis ampelophila Blanchard, 1913.

This is a large, black North American species which commonly feeds on grapes and related plants.

Chile:

On a wild *Berberis* sp., 2 km. west of Porto Veras, Province of Llanquihue, January 17, 1951. Only a few alates and apterous forms.

Argentina:

This species is reported by Blanchard (1923, pp. 33–35; 1931, p. 1002) on grape, *Vitis* sp.

It was also described from specimens taken in Argentina by Del Guercio (1913, p. 159) as *Aphis ampelophila* which is a synonym of *A. illinoisensis.*

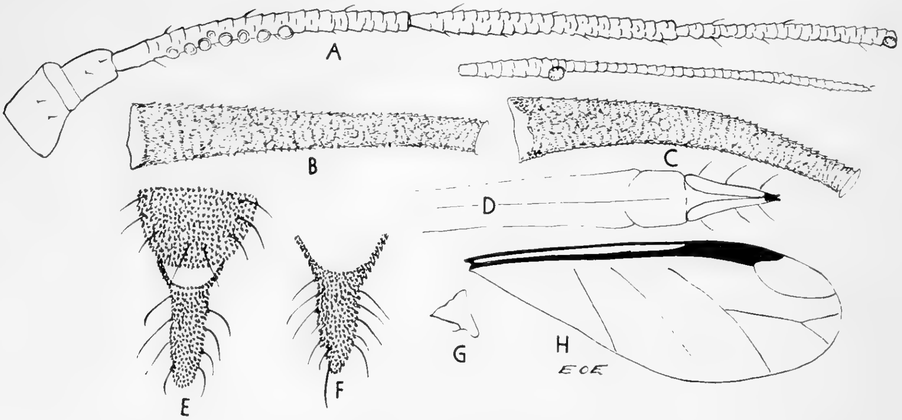


Figure 18. Grapevine aphid, *Aphis illinoisensis* Shimer. A, antenna of alate; B, cornicle of alate; C, cornicle of aptera; D, rostrum of alate; E, cauda and anal plate of alate; F, cauda of aptera; G, prothoracic tubercle; H, forewing.

Aphis marthae Essig, new species

Cabildo Aphid

(Figure 19)

Type: *Alate parthenogenetic female*: A large species, black and pale in various patterns, one of which is figured. Antennae black, shorter than

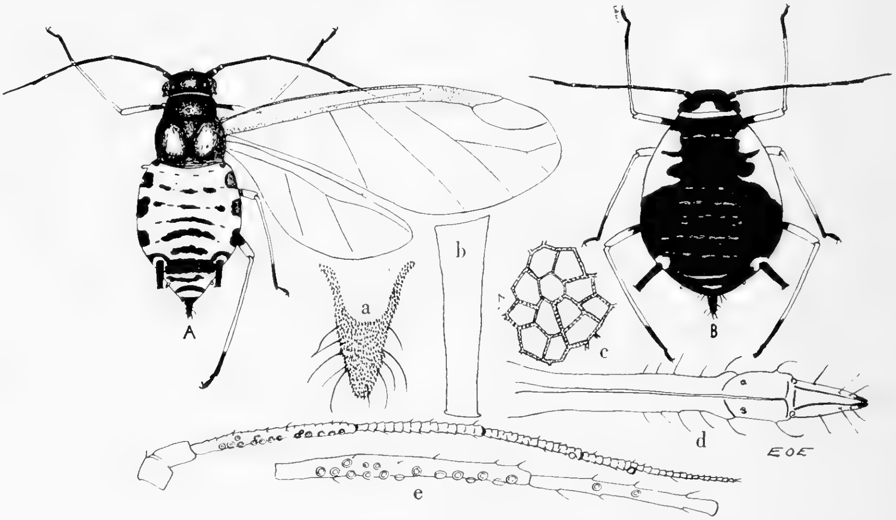


Figure 19. Cabildo aphid, *Aphis marthae* Essig, new species. A, alate; B, aptera. a, cauda and b, cornicle of alate; c, reticulations on dorsum of aptera; d, cornicle and e, antennae of alate.

the body; unguis about twice the length of the base; segment III with a variable number of small and large, circular sensoria, numbering 11–16 and distributed over much of the length. (Paratypes show the following pattern: 11–14, 11–15, 12–15, 12–16, 13–14, 13–16, 15–15, 15–18, 16–18, 16–19, 17–19, 17–21, 18–18, etc.); IV with 1–2 sensoria. (Paratypes with the following numbers: 0–1, 0–2, 0–3, 1–2, 1–3, 2–3, 2–4, 5–X); with few short hairs. Rostrum quite wide with two apical segments about equal in length; with hairs as shown. Primary wings large with second branch of media one-third distance from first fork. (This character is variable in paratypes. The branch may be near or even forward of the middle and in one instance the media had but a single branch.) Length 3.3 mm. Cornicles short, almost cylindrical, imbricated; 0.25 mm. long. The area around the base is pale. Cauda slightly shorter than the cornicle, with 11–12 hairs. Length of body 2.5 mm.

Apterous parthenogenetic female: Of the same general shape, size, and color of *Aphis medicaginis* Koch which it also resembles in having the mosaic pattern on the dorsum of the abdomen. Shining black with portions of the legs and body paler. The pale areas surrounding the bases of the cornicles are specially noticeable. The pigmented color pattern on the dorsum varies considerably and may depend upon the development and age of the individual. Nearly full grown individuals have little dark markings. Length of body 2.50 mm.; antennae 1.60 mm.; cornicles 0.30 mm.; cauda 0.30 mm.

Host plant and locality: This species was collected on an undetermined shrub or tree at **Cabildo, Province of Aconcagua, Chile,** November 28, 1950, by Dr. A. E. Michelbacher. A large number of apterae and alatae were taken.

Type and paratypes: A singe alate individual has been designated as the type and the remaining 5 alatae and 20 apterae are designated as paratypes.

This species most resembles *Aphis rumicis* Linnaeus, but differs in the following respects: The body is much more heavily pigmented; there are fewer sensoria on antenal segment III in the alatae; the unguis of the antennae is much shorter; the rostrum is more robust and the apical segments longer, the cauda is more tapering and with fewer hairs.

It differs from *Aphis medicaginis* Koch in having many more sensoria on antenal segment III and in also having a few sensoria on segment IV; and in having the apical segments of the rostrum broader.

It differs from *Aphis bazzi* Blanchard in being more heavily pigmented; with shorter antenal unguis; in having fewer sensoria on antennal segment IV; and in being much larger in size: 2.50 mm. as compared with 1.80 mm.

It was named for Mrs. Martha Michelbacher, one of its collectors, in recognition for her contributions to the South American aphid survey.

Aphis medicaginis Koch,[3] 1854

Cowpea Aphid

(Figure 20)

This aphid is shiny black in life, especially the apterous forms with the distal portions of the legs distinctly whitish. When cleared and mounted they appear as illustrated. This aphid is quite common, especially on species of *Leguminosae,* and occurs throughout much of the world and is widely distributed in South America as indicated by the collections made by Dr. Michelbacher and others.

CHILE:

On thorny legume (*Cassia* sp. ?), Valparaiso, November 17, 1950; many apterae,

On *Cassia* sp. Pedegua, Province of Aconcagua, November 28, 1950. Many apterae and 1 alate.

On thorny legume, Illapel, Province of Coquimbo, November 28, 1950 —10 apterae.

On *Artemisia* sp. ?, 90 km. east of end of tunnel, Illapel, November 28, 1950—5 apterae and 1 alate.

On Composite (*Artemisia* sp. ?), 90 km. east of end of tunnel, Illapel, November 28, 1950—6 apterae and 2 alatae.

On *Cereus* sp., Las Palmas, Province of Aconcagua, November 29, 1950—apterae and alatae.

On *Cassia* sp. ?, Illapel, Province of Coquimbo, November 30, 1950—apterae only.

On yellow-flowered cactus (cacto), La Serena, Province of Coquimbo, December 2, 1950—apterae only.

On legume (?), Huanta, Province of Coquimbo, December 6, 1950—apterae and alatae.

On woody shrub, Los Vilos, Province of Coquimbo, December 14, 1950 —alates and apterae.

---

[3] D. Hille Ris Lambers informs me that he does not believe that the European *Aphis medicaginis* Koch occurs in America and that what we have been calling that species is probably *Aphis craccivora* Koch. In my collection there is a good series of this European species collected on *Vicia cracca* L. in Belgium at Visé by A. Collart, 1938, and at Weerde by E. Janmoulle in 1939. These appear much like our American *Aphis medicaginis* Koch in general appearances, but differ in having much shorter cornicles; greater number of caudal hairs; and a somewhat shorter filament, unguis or processus terminalis. It is quite possible that our species is distinct.

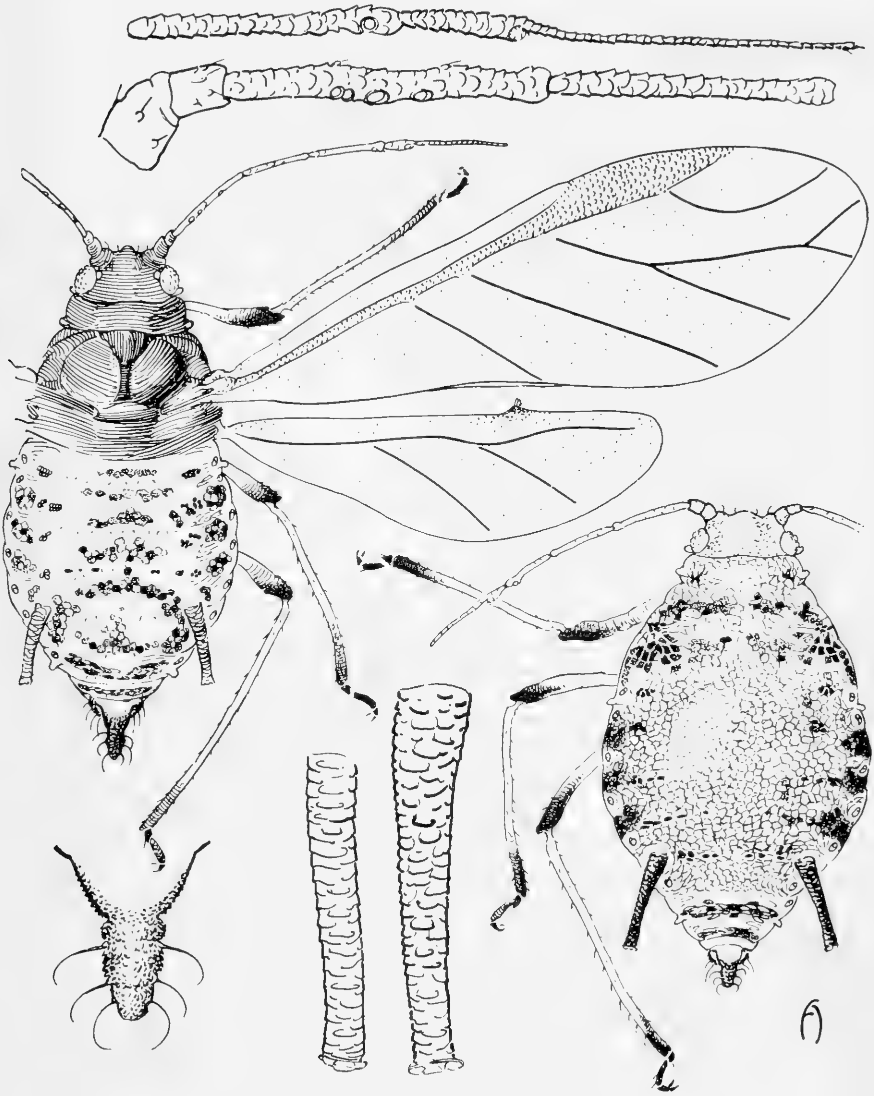


Figure 20. Cowpea aphid, *Aphis medicaginis* Koch. Adults and antenna, cauda and cornicle of aptera. (After Zimmerman, 1948.)

On leguminous tree, Valparaiso, December 17, 1950—apterae and alatae.

On *Baccharis* sp. ?, Chillan, Province of Nuble, December 27, 1950—many apterae and 1 alate. Very small specimens.

On thorny legume, Antuco, Province of Bio-Bio, December 28, 1950—apterae only.

On thorny legume, El Abanico, Province of Bio-Bio, December 30, 1950—alatae and apterae.

On *Solanum* sp., Los Andes, Province of Aconcagua, February 4, 1951, many apterae and alatae.

On wild nasturtium (nasturcia), Portillo (3,000 feet), Province of Aconcagua, February 4, 1951. Many apterae and alatae.

Argentina:

On *Astragalus* sp. ?, La Quiaca, Province of Jujuy, February 18, 1951—many specimens apterae and alatae.

In addition, Blanchard (1939, pp. 914–916; pp. 922–923) lists the following host plants (as *Aphis fabae* Scopoli and *A. laburni* Kaltenbach):

Acacia sp., *Arachis hypogaea* L., *Cicuta* sp., *Dyckia floribunda* Gris., *Eryngium* spp., *Euonymus* sp., *Eucalyptus* spp., *Foeniculum vulgare*, *Gladiolus* sp., *Cirsium* sp., *Chrysanthemum* sp., *Cosmos* sp., *Dahlia* sp., *Phaseolus lunatus* L., *Phoenix* sp., *Gerbera jamesoni*, *Senecio bonariensis* H. & A., *Sesbania punicea* (DC), *Spiraea chamaedrifolia* L., *Vicia* sp.

The writer has recently received specimens from L. A. Bahamondes collected by him as follows:

On *Solanum* sp., Mendoza, October 3, 1948—many apterae.

On a Composite, Mendoza, February 10, 1948—many apterae.

On *Gloxinia* sp., Mendoza Capital, March 10, 1948—a few apterae.

Colombia:

On legume, Buenaventura, November 4, 1950. Collection consisted of 21 apterous females.

Peru:

On broad bean, *Vicia faba*, Callao, November 4, 1950—5 alates and 10 apterae.

On *Astragalus* sp., Sicuana, Province of Cusco, March 1, 1951—many specimens, all apterae.

On *Cassia* sp., Cusco, Province of Cusco, March 2, 1951—many specimens—all apterae.

On thorny legume, Cusco, Province of Cusco, March 2, 1951—all apterae.

Aphis nerii Boyer de Fonscolombe, 1841

Oleander Aphid

(Figure 21)

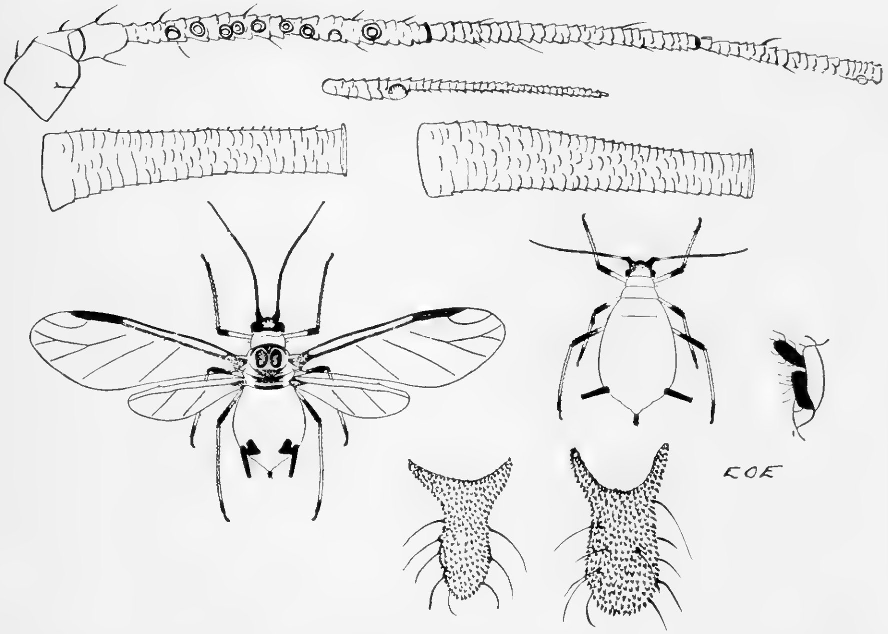


Figure 21. Oleander aphid, *Aphis nerii* (Boyer de Fonscolombe). Alate and apterous parthenogenetic females with enlarged antenna of alate and cornicles and caudas of alate and apterous forms. A bright yellow and black species.

Cerosipha nerii (Boyer de Fonscolombe) Börner, 1952.

This is a widely distributed aphid occurring on *Asclepias* spp., *Caltrophis* spp., *Gonolobus* spp., and related genera in Europe, Asia, South Pacific Islands, North and South America, and Africa.

Chile:

On oleander, *Nerium* sp. (adelfa, baladre), Antofagasta, November 22, 1950; many apterae and alatae.

On an unknown host, south slope of Bell Mountain, Province of Aconcagua, December 17, 1950—1 alate.

Beating (plants not ascertained) near the mouth of Maullin River, Province of Llanquihue, January 22, 1951—a large number of apterae and alatae.

Bolivia:

On *Asclepias* sp., Cumergo, February 20, 1951—many apterae and alatae.

Argentina:

On *Nerium oleander* L., *Araujia sericofera* Bert., *Asclepias curassavica* L., and *Clematis* sp. (Ornamental) by Blanchard (1923, pp. 39–41; 1939, pp. 925–26).

Peru:

On a vine-like *Asclepias* (?), 65 miles west of Cusco, March 5, 1951—3 alatae.

On *Asclepias* sp., Chiclayo, Province of Lambayeque, March 19, 1951—all apterae.

Aphis rumicis Linnaeus, 1758

Bean or Dock Aphid

(Figures 22–25)

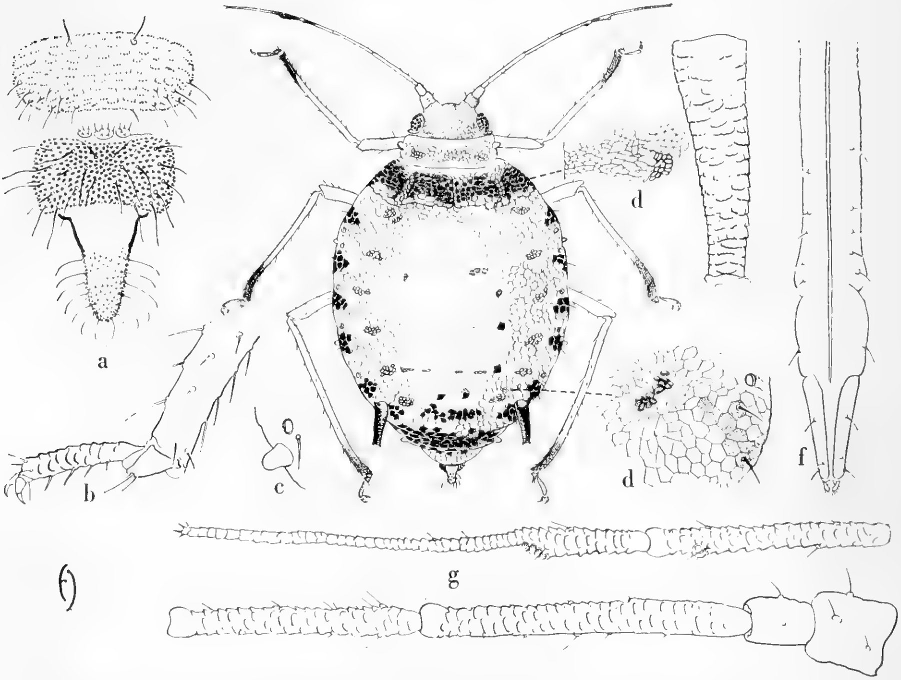


Figure 22. Bean or dock aphid, *Aphis rumicis* Linnaeus. Apterous parthenogenetic female and enlargements of a, anal plate and cauda; b, tarsus; c, lateral abdominal tubercle; d, mosaic and glandular areas; e, cornicle; f, rostrum; g, antenna.

Almost a cosmopolitan species which is widely distributed throughout most of the world. It feeds upon many different hosts. The following collections were made:

Chile:

On *Chrysanthemum* sp., Antofagasta, November 21, 1950—apterae only.

On *Epiphyllum* cactus, in a garden at La Serena, Province of Coquimbo, December 2, 1950—apterae and alatae.

On a native shrub, 10 miles below Laguna Dam, 6,000–7,000 feet, December 6, 1950. Plant heavily infested—only apterae collected.

On *Rumex* sp., Hacienda San Andres, near Purranque, Province of Llanquihue, January 1, 1951—all apterae.

On thistle (*Cirsium* sp. ?), Angol, Province of Malleco, January 1, 1951; all apterae.

Beating at Hacienda San Andres, near Purranque, Province of Llanquihue, January 15, 1951—a few apterae.

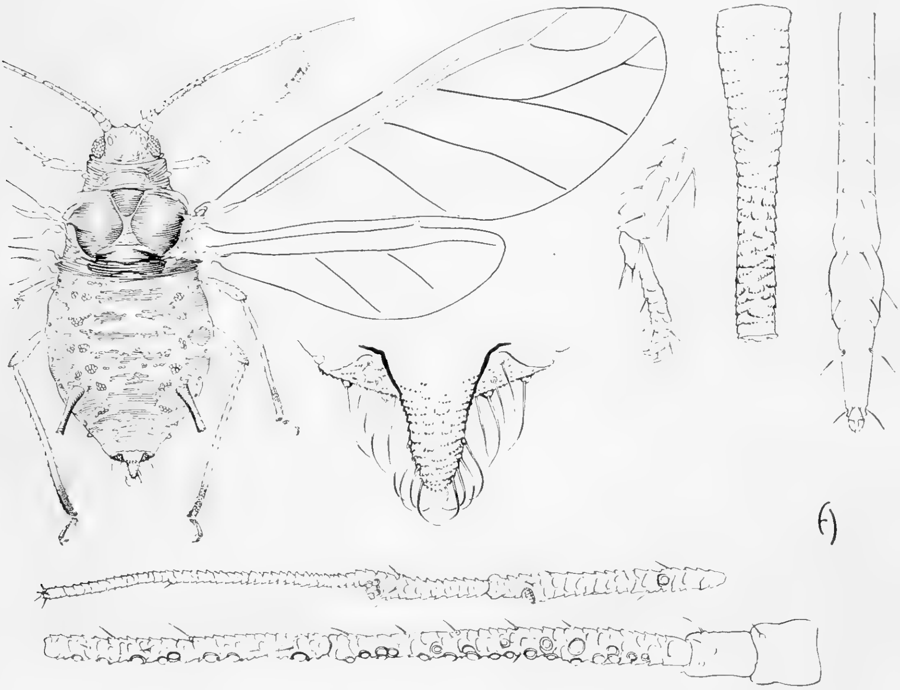


Figure 23. Bean or dock aphid, *Aphis rumicis* Linnaeus. Alate parthenogenetic female and enlarged cauda, tarsus, cornicle, rostrum (venter), and antenna.

On wild currant ? (grosellers), Hacienda San Andres, Parranque, Province of Llanquihue, January 15, 1951—apterae and alatae.

Argentina:

On wild potato (papa), Salta, Province of Salta, February 15, 1951—1 single alate.

On *Solanum* sp., Salta, February 15, 1951—many specimens; many apterae and 1 alate.

On thorny legume, Jujuy, Province of Jujuy, February 15, 1951—many specimens, all apterae.

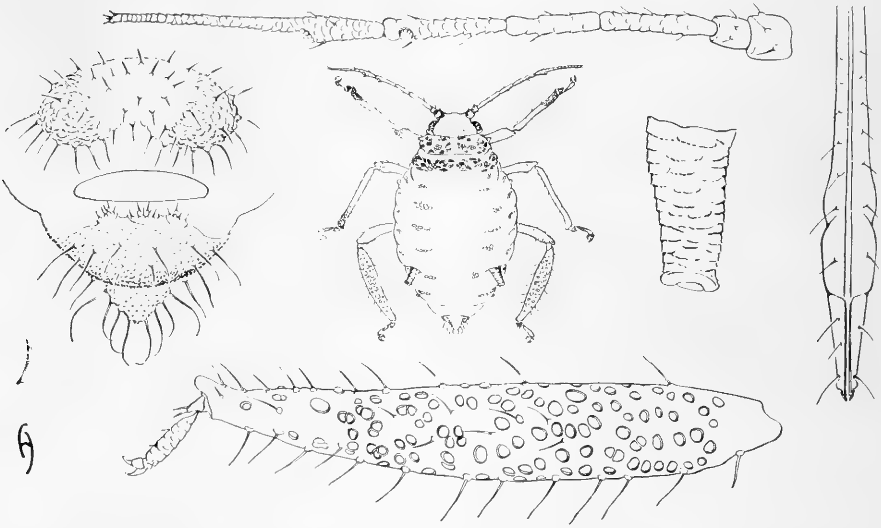


Figure 24. Bean or dock aphid, *Aphis rumicis* Linnaeus. Sexual female and enlarged anal plate and cauda, antenna, cornicle, rostrum (venter) and hind tibia showing sensoria.

On *Solanum* sp., Jujuy, February 16, 1951—many apterae and alatae. Blanchard (1935: 373–375; 1939: 929–930) records it

On *Rumex* sp., at Tucuman.

On *Rumex* sp., *Cestrum parqui* L.'Herit, *Solanum lycopersicum* L., *S. nodiflorum* Jacq., *S. capsicastrum* Link., and other solanums.

The writer has recently received specimens from L. A. Bahamondes, collected by him as follows:

On *Chaenomeles japonica* (Thunb.) Lindl., at Mendoza, October 20, 1950—3 apterae and 2 alatae.

On *Tulipa* sp., Las Heras, Mendoza, October 10, 1950—apterae and alatae.

On *Rumex* sp., Mendoza, Guaymallen y Capital, November 1, 1950—apterae only.

On *Eugenia* sp., Mendoza Capital, May 10, 1948—apterae.

On *Solanum* sp. (beating), Ando Huylas, Province of Mendoza, February 15, 1951—1 alate.

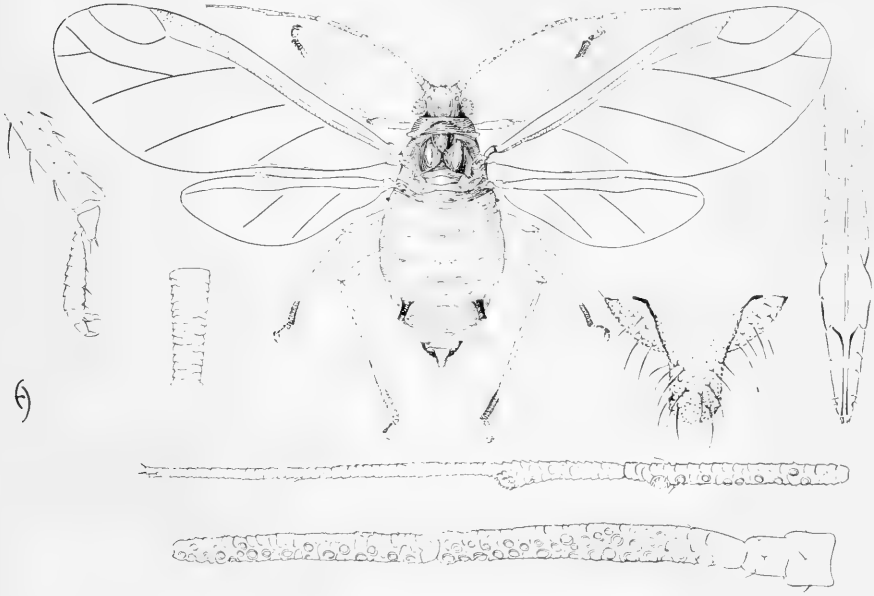


Figure 25. Bean or dock aphid, *Aphis rumicis* Linnaeus. Alate and enlarged tarus, cornicle, anal plate and cauda, rostrum, and antenna of same.

Peru:

On *Agave* sp., Rio Pampas, Province of Purimac, March 8, 1951—many apterae and alatae. About 60 per cent killed by a fungus (hongo).

On *Composite* (?), on road 65 miles west of Cusco, March 5, 1951. Only apterae.

On *Composite*, Cusco, March 5, 1951—1 alate.

Toxoptera aurantii (Boyer de Fonscolombe)

Black Citrus Aphid

(Figure 26)

Aphis aurantii Boyer de Fonscolombe, 1841; *Aphis camelliae* Kaltenbach, 1843; *Toxoptera aurantiae* Koch, 1856.

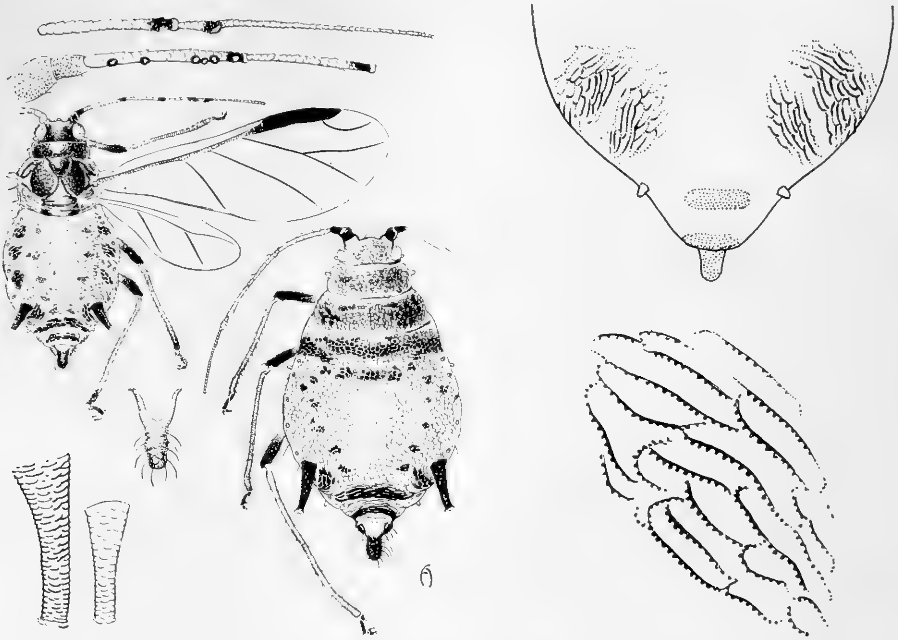


Figure 26. Black citrus aphid, *Toxoptera aurantii* (Boyer de Fonscolombe). At left: alate and apterous parthenogenetic females with enlarged antennae, cauda, and cornicles. (After Zimmerman, 1948); at right: net-like saw-toothed reticulations on the venter beneath the bases of the cornicles, which are found so far only in this species and in *Aphis citricidus* (Kirkaldy).

This species is widely distributed throughout the tropical and subtropical regions of the world and feeds upon such plants as those belonging to the genera *Camellia, Cinchona, Citrus, Coccoloba, Coffea, Ficus, Gardenia, Hibiscus, Ilex, Mangifera, Persea, Straussia, Theobroma,* and others. Strangely enough only a single collection was made on this expedition in South America and that in Colombia.

Argentina:

This species is quite common throughout the Provinces of Buenos Aires, Entre Rios, Corrientes, Santa Fe, and Tucuman, according to Blanchard (1925, pp. 20–22; 1939, pp. 903–904; 1944, p. 18).

On *Citrus* spp., *Ilex paraguariensis* Bonop., *Mandevilla suaveolens* Lindl., *Phytolacca dioica* L., *Scutia buxifolia* Reiss., and *Viburnum tinus* L.

Colombia:

On mango (*Persea* sp.), Buenaventura, November 5, 1950—many apterae.

Subfamily **ANURAPHINAE**

Tribe **Anuraphidini**

Subtribe **Anuraphidina**

Brachycaudus helichrysi (Kaltenbach)

Leaf-curl Plum Aphid

(Figure 27)

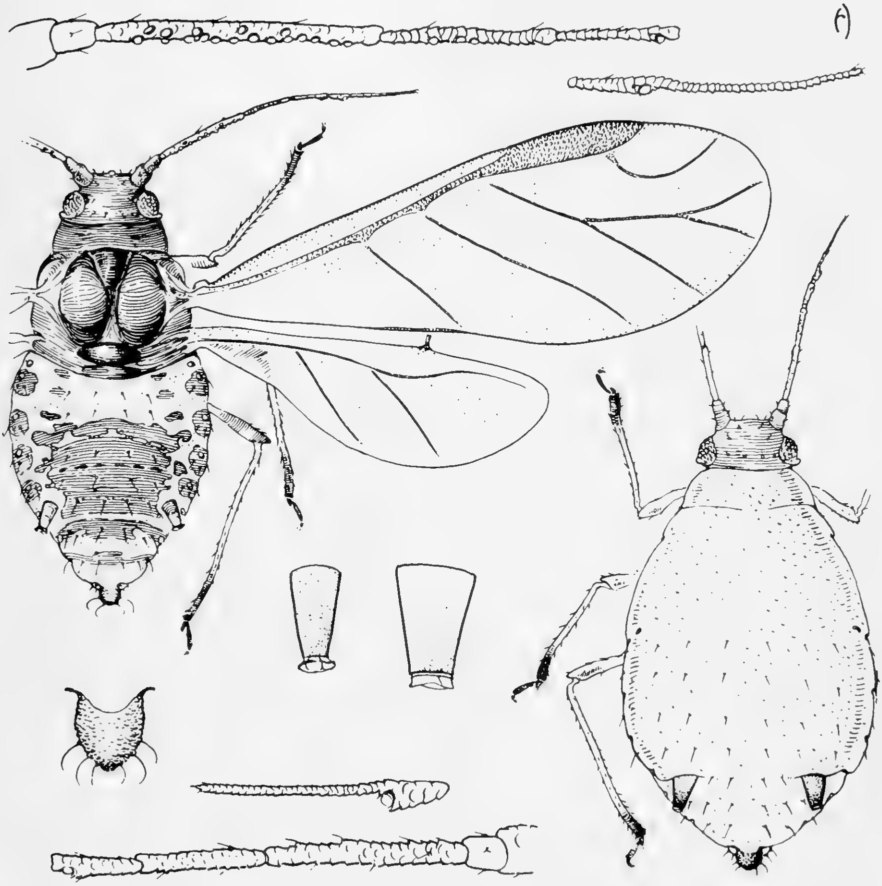


Figure 27. Leaf-curl plum aphid, *Brachycaudus helichrysi* (Kaltenbach). Alate and apterous parthenogenetic females with enlarged antennae, cornicles, and cauda. (After Zimmerman, 1948.)

Aphis helichrysi Kaltenbach, 1843; *A. bartsiae* Walker, 1848; *A. bellis* Buckton, 1879; *A. verbenae* Macchiati, 1883; *A. leonopedii* Schouteden, 1903; *Anuraphis cyani* Theobald, 1915; *A. abrotaniella* Theobald, 1919; *A. cantauriella* Theobald, 1921; *A. sherardiae*, Theobald, 1926.

This small, pale aphid has conspicuous dark body markings. It is widely distributed throughout the temperate regions of the world and attacks many kinds of plants.

CHILE:

Very abundant on peach (*Prunus persica*) causing the leaves to curl at Rivadava, Province of Huanta, December 4, 1950. Very many apterous and but one alate were collected at the time. The alatae were just beginning to appear.

On the wing at Los Muermos, Province of Llanquihue, January 20, 1951—1 alate and many apterae.

ARGENTINA:

Blanchard (1922, pp. 54–56) reports this species often abundant on peach and says it is "the chief enemy of the peach and causes much damage in the spring to the young foliage, which soon becomes curled and distorted."

On *Senecio* sp., *Aster* sp., *Prunus* sp., and Compositae in the Province of Buenos Aires. (Blanchard 1922, p. 52, fig. 17; 1939, p. 894).

On *Cineraria* sp., Pampa (Blanchard 1944, p. 57).

Specimens have also been received from L. A. Bahamondes:

On (ortiga) nettle, Godoy Cruz, Mendoza Capital, November 20, 1950 2 alatae.

PERU:

On Shasta daisy, *Chrysanthemum maximum* (?), Lima, November 15, 1950—apterae and alatae.

On potato, *Solanum tuberosum*, 3,000 meters altitude, Sicuana, Province of Cusco, March 2, 1951. Alatae only.

On marigold, *Calendula officinalis*, Callao, November 14, 1950—6 apterae and 6 alatae.

On *Chrysanthemum* sp., Botanical Garden, Lima, November 13, 1950 —3 apterae.

Tribe **Brachycolini**

Brevicoryne brassicae (Linnaeus)

Cabbage Aphid

(Figures 28–29)

Aphis brassicae LINNAEUS, 1758; *Brevicoryne brassicae* (Linnaeus) VAN DER GOOT, 1915.

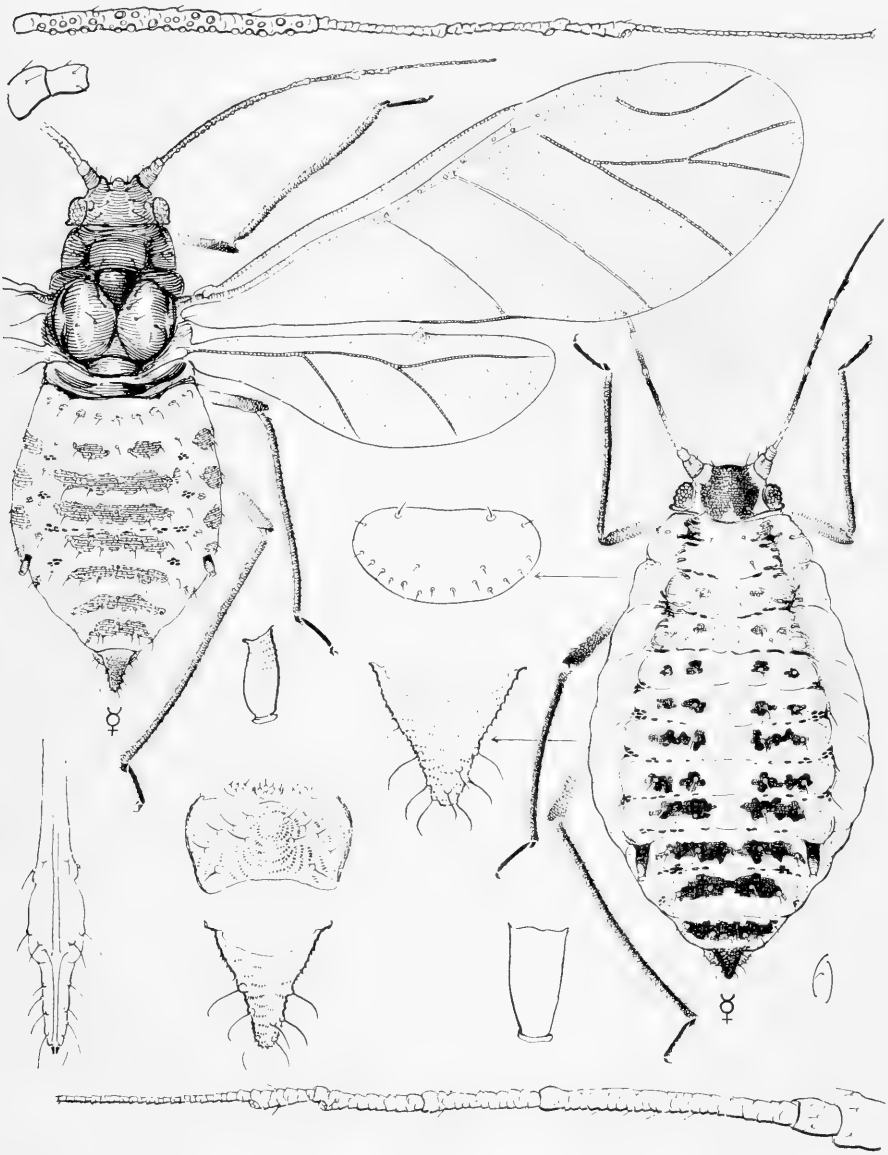


Figure 28. Cabbage aphid, *Brevicoryne brassicae* (Linnaeus). Alate and apterous parthenogenetic females and enlarged genital plates, caudas, cornicles, rostrum, and antennae.

This very common aphid appears to be a Holarctic species, although it may well have been early introduced into the Americas from Europe. It has become widely distributed throughout much of the world by commerce.

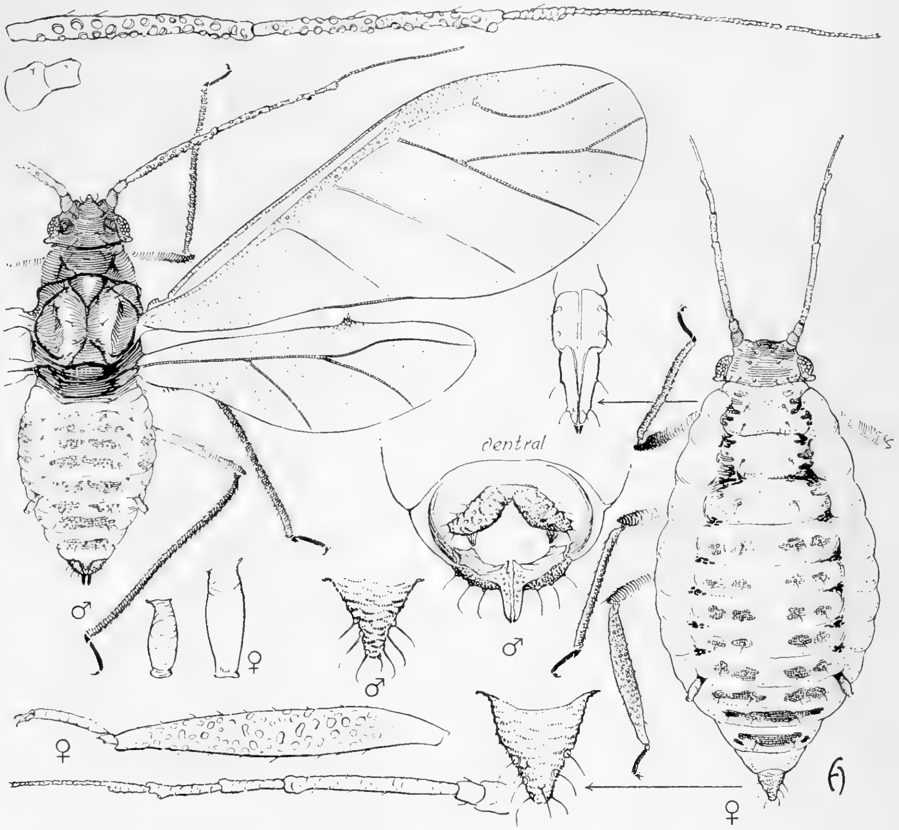


Figure 29. Cabbage aphid, *Brevicoryne brassicae* (Linnaeus). Alate male and apterous female with enlarged antennae, rostrum, cornicles, caudas, male genitalia, and female hind femur with sexual sensoria.

CHILE:

On cabbage, *Brassica oleracea* var. *capitata,* at Purranque, Province of Osorno, January 17, 1951—many apterae and alatae.

ARGENTINA:

"Common everywhere in Argentina on *Brassica* spp., *Raphanus* spp., and *Spinacia oleracea.*" (Blanchard, 1925, pp. 12–14.)

PERU:

On mustard (*Brassica* sp.), Callao, November 14, 1950—many apterae and alatae.

On Caper-bush, *Capparis spinosa,* Botanical Garden, Lima, November 14, 1950.

Hyadaphis conii (Davidson)

Honeysuckle Aphid

(Figure 30)

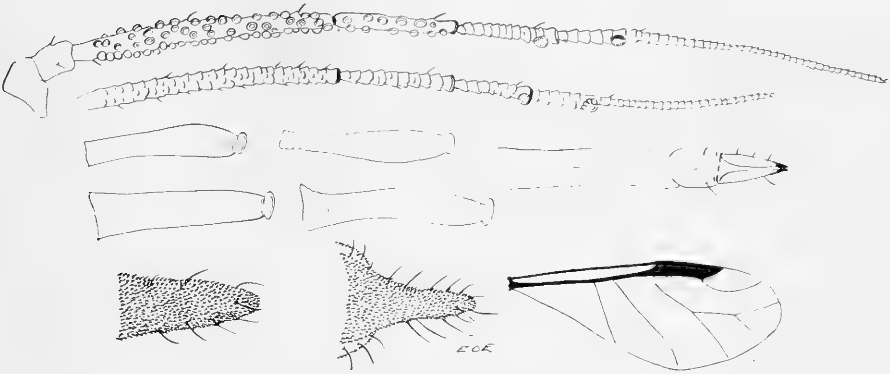


Figure 30. Honeysuckle aphid, *Hyadaphis conii* (Davidson). Enlarged drawings of antennae, cornicles, rostrum, caudas, of aptera and alate and wing of alate.

Siphocoryne conii Davidson, 1909; *Aphis xylostei* Schrank, 1801; *Hyadaphis coniella* Theobald, 1925; *H. sii* Börner, 1931-32; *Rhopalosiphum melliferum* Hottes, 1930.

This species is widely distributed in temperate regions and is common in Europe and North America and also occurs in Africa and South America. It particularly infests *Lonicera* spp. and members of the large family Umbelliferae.

Chile:

A single collection of many apterae and alatae was made on *Carum* sp. (?), 60 kilometers east of Los Andes, Province of Aconcagua, February 4, 1951.

Tribe **Liosomaphidini**

Cavariella aegopodii Scopoli

Parsnip and Willow Aphid

(Figure 31)

Aphis aegopodii Scopoli, 1763; *Cavariella capreae* (Fabricius), 1775 (Many authors).

This is probably a Holarctic species commonly occurring in Europe and North America. It has been introduced into many parts of the world.

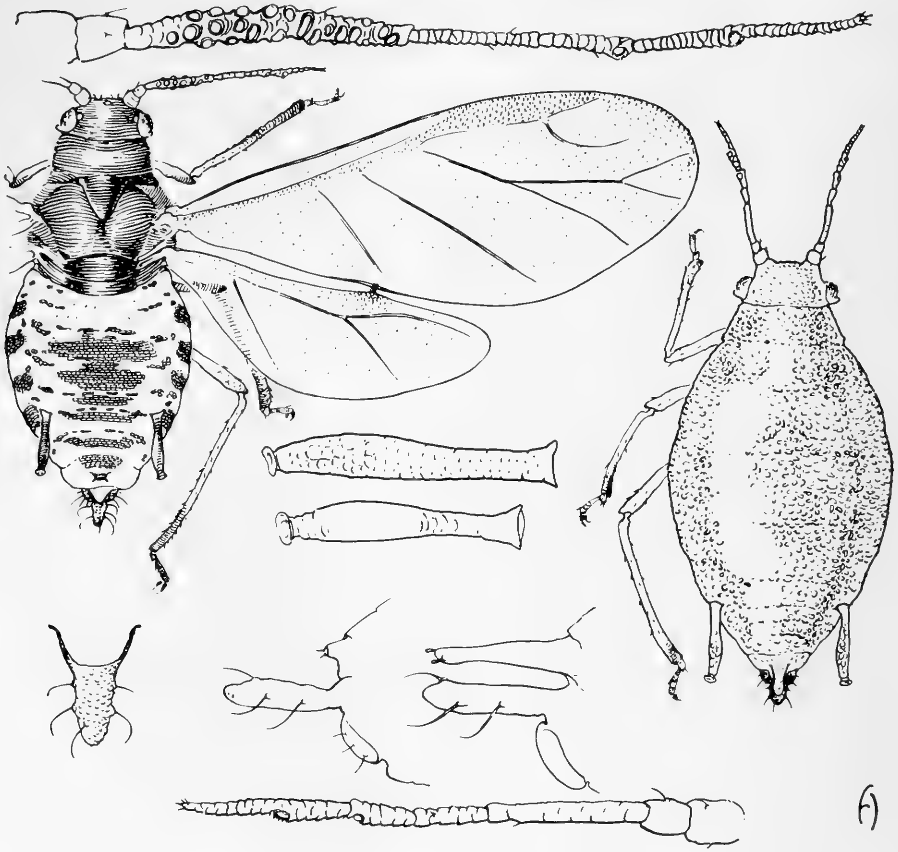


Figure 31. Parsnip and willow aphid, *Cavariella aegopodii* (Scopoli). Alate and apterous parthenogenetic females and enlarged antennae, cornicles, caudas, and caudal tubercle of female (lateral aspect). (After Zimmerman, 1948.)

Chile:

In Chile it appears to be widely distributed on umbelliferous plants and was collected as follows:

On an umbelliferous plant, at La Ligura, Province of Aconcagua, December 14, 1950—apterae and alatae present in large numbers.

On anise or dill, *Anethum graveolens,* Angol, Province of Bio-Bio, January 1, 1951—many apterae and alatae.

On a wild host and by beating various plants at Hacienda San Andres, Purranque, Province of Osorno, January 15, 1951—apterae and alatae.

Argentina:

Under the above specific name and also as *C. capreae* (Fabricius) this species has been recorded:

On *Apium* sp., *Daucus* sp., *Carum* sp., *Pastinaca* sp., *Pimpinella anisum* L., and *Salix* sp. (Blanchard 1925, pp. 14–16; 1944, pp. 31–32).

Specimens have been received from L. A. Bahamondes, collected on *Salix babylonica* L., Guaymallen, Province of Mendoza, November 28, 1951; many apterae and alatae.

Tribe **Myzini**

Subtribe **Myzina**

Myzus circumflexus (Buckton)

Lily Aphid

(Figure 32)

Siphonophora circumflexa Buckton, 1876; *S. callae* Heinrich, 1909: *Myzus vincae* Gillette, 1908.

This is a European species now widely distributed on lilaceous plants. The insect infests both the bulbs and foliage. The pale green or yellowish apterae have conspicuous dark markings on the dorsum of the abdomen.

Chile:

A single apterous female was taken by beating at Purranque, Province of Osorno, January 15, 1951.

Argentina:

This species has also been collected upon a number of hosts in the Province of Buenos Aires, by Blanchard (1922, pp. 213–4, fig. 15; 1939, p. 976; 1944, p. 43) as follows:

On *Citrus* sp., *Cyclamen* sp., *Tulipa* sp., and other Lilaceae, Orchidaceae, and *Vinca* major L.

Myzus ornatus Laing, 1932

Ornate Aphid

(Figure 33)

This species appears to have been introduced into England, where it was first noted on violets by Laing (1932) and described. Since then the writer has received specimens collected upon many host plants (Essig, 1938, 1939, 1947). It appears that this insect may be a native of South

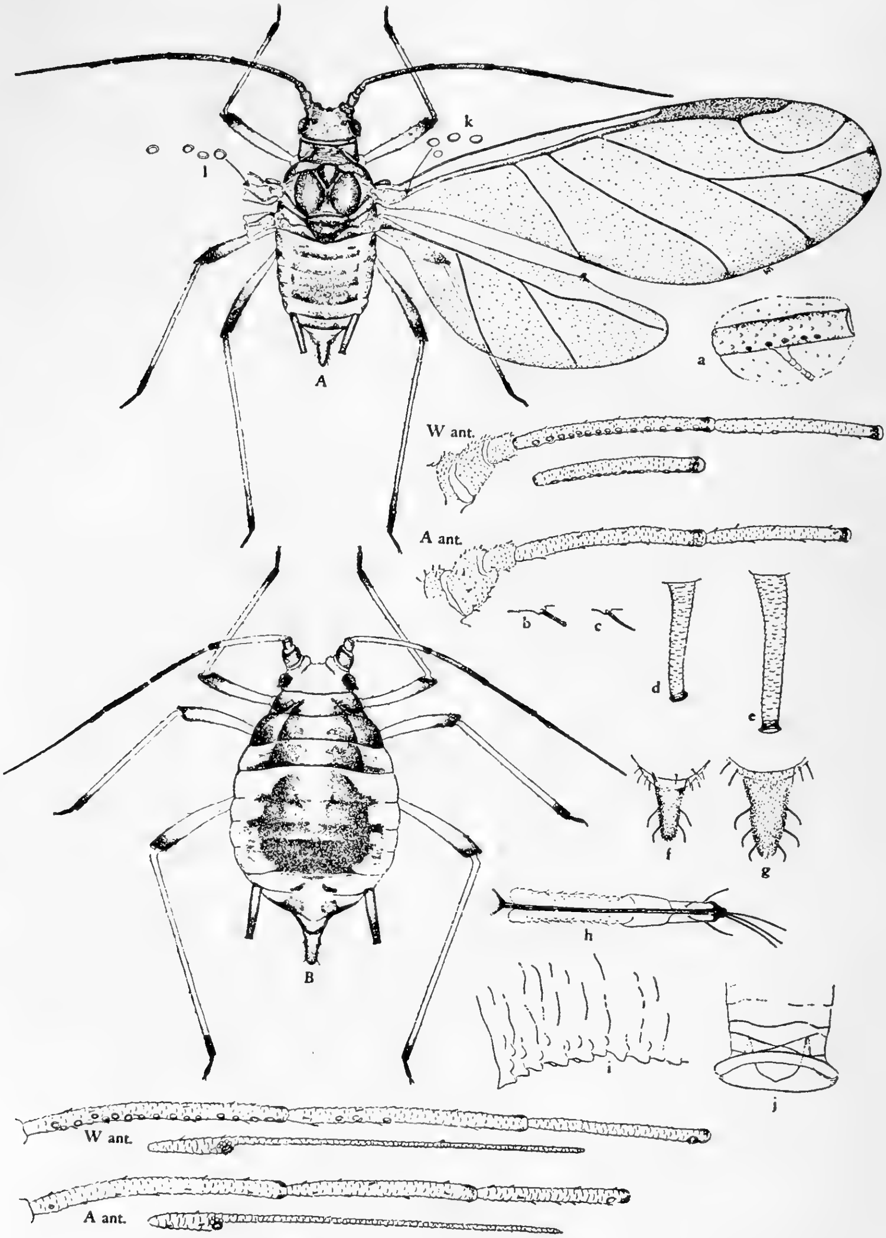


Figure 32. Lily aphid, *Myzus circumflexus* (Buckton). A, adult winged female; a, section of the costal vein showing fenestralike areas; d, cornicle; f, cauda; k and l, fenestras near the base of the subcostal vein; W, ant., antennae. B, adult apterous female: A, ant., antenna; b and c, setas on segments I and III of antenna; e, cornicle; g, cauda; h, rostrum; i, basal margin of cornicle; j, tip of cornicle. All greatly enlarged. A yellow and black species.

America where it is associated with plants of the genera *Fuchsia* and *Begonia* and perhaps other indigenous plants.

CHILE:

On *Cereus* sp., at Las Palmas, Province of Aconcagua, November 29, 1950, along with some other aphids.

On *Bignonia* sp., Antofagasta, November 21, 1950—3 apterae.

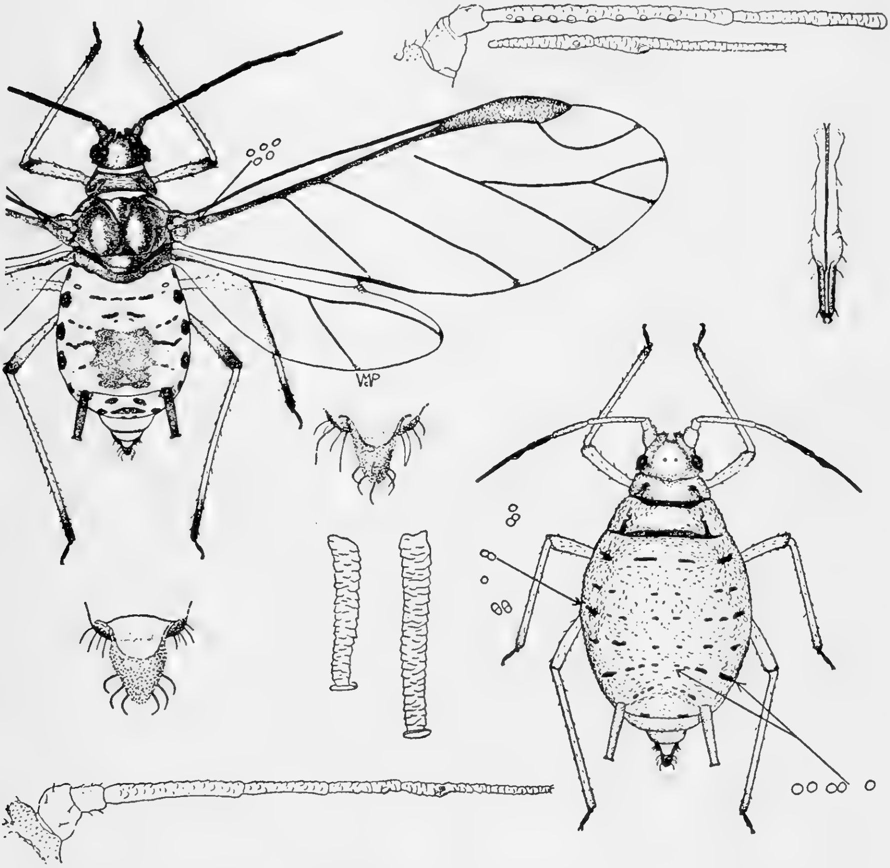


Figure 33. Ornate aphid, *Myzus ornatus* Laing. Alate and apterous parthenogenetic females with enlarged antennae, caudas, cornicles, and rostrum.

Myzus persicae (Sulzer)

Green Peach Aphid

(Figure 34)

Aphis persicae SULZER, 1776; *Aphis dianthi* SCHRANK, 1801; *A. persicæcola* BOISDUVAL, 1867; *Myzus malvae* OESTLUND, 1886; *Phorodon cynoglossum* WILLIAMS, 1910; *Rhopalosiphum betae* THEOBALD, 1913.

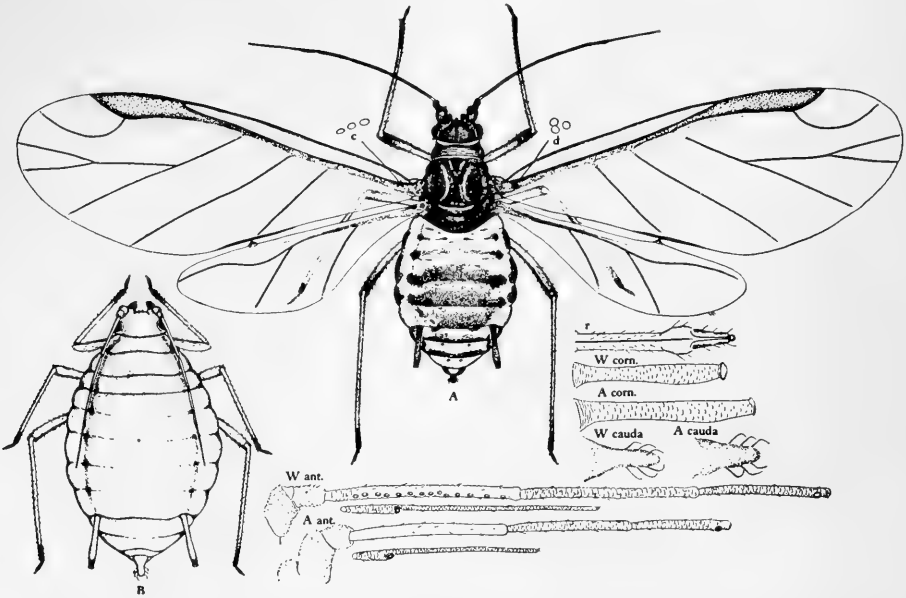


Figure 34. Green peach aphid, *Myzus persicae* (Sulzer). A, alate parthenogenetic female; B, apterous female. Enlarged rostrum; cornicles, caudas, and antennae. A yellow, green and black species.

This is one of the most widely distributed aphids and occurs on all the continents. It has an enormous number of host plants and is the most important aphid vector of plant virus diseases (Essig 1948b).

CHILE:

On *Datura* sp., Antofagasta, November 21, 1950—10 apterae.

On *Cereus* sp., Las Palmas, Province of Aconcagua, November 29, 1950—a few specimens, all apterae.

On wild morning glory, *Convolvulus* sp., Angol, Province of Bio-Bio, January 1, 1951—1 alate and 3 apterae.

ARGENTINA:

This aphid is widely distributed throughout this country and has been reported upon many host plants including:

Abutilon sp., *Antirrhinum* sp., *Bellis* sp., *Beta* sp., *Brassica* sp., *Cannabis sativa* L., *Capsicum* sp., *Chenopodium* sp., *Cineraria* sp., *Cosmos* sp., *Cuminum cyminum* L., *Cynara* sp., *Descurainia appendiculata* (Gris.), *Dianthus* sp., *Lonicera* sp., *Malva* sp., *Pimpinella anisum* L., *Prunus* spp., *Pyrus* sp., *Senecio* sp., *Solanum* spp., *Tulipa* sp., *Vinca* sp. (Blanchard 1922, pp. 211–213, fig. 13; 1939, pp. 980–981; 1944, p. 43).

The writer has also received specimens from L. A. Bahamondes, collected by him as follows:

On alheli, stock or gilliflower, *Matiola incana* L., Mendoza Capital, October 3, 1948—4 alatae.

On *Begonia,* Mendoza Capital, March 7, 1949—many specimens.

On nettle, ortiga, *Urtica urens,* Godoy Cruz, Mendoza Capital, November 20, 1950.

On *Tulipa* sp., at Mendoza, October 13, 1950—1 aptera and 1 alate.

On *Rumex* sp., Mendoza, Guaymallen y Capital, November 1, 1950—several specimens

On *Barnadesia odorato* (?) Mendoza Capital, November 1, 1950—many specimens.

Bolivia:

On cultivated potato (patata, papa), at Camargo, February 22, 1951—2 apterae.

Peru:

On caper-bush, *Capparis spinosa,* Botanical Garden, Lima, November 14, 1950—2 apterae and 1 alate.

On *Phlox* sp., Lima, November 15, 1950—many apterae.

On tobacco, *Nicotiana* sp., Botanical Garden, Lima, November 14, 1950—1 alate.

On *Solanum* sp., Callao, November 14, 1950—2 alates.

On potato, *Solanum tuberosum,* Callao, November 16, 1950—1 alate and 3 apterae.

On *Datura* sp., Botanical Garden, Lima, November 14, 1950—2 alatae and 4 apterae.

By beating nightshade, *Solanum* sp., Andahuaylas, Province of Apurimac, March 7, 1951—6 apterae and 1 alate.

On cultivated potatoes, Sicuani, Province of Cusco, March 2, 1951—4 alates.

On thorny tree by beating, Abancay, Province of Apurimac, March 6, 1951—1 aptera.

By beating, Rio Pampas, Province of Ayacucho, March 8, 1951—3 apterae.

Tribe **Cryptomyzini**

Capitophorus braggi (Gillette)

Artichoke Aphid

(Figure 35)

Myzus braggii GILLETTE, 1908.

This pale yellow and greenish aphid often appears in overwhelming numbers on artichoke and other hosts.

CHILE:

On artichoke (alcaucil) *Cynara scolymus,* San Carlos, Province of Nuble, December 23, 1950. Many apterae and a few alatae.

No host record; 50 km. east of San Carlos, Province of Nuble, December 25, 1950—4 alates. Collected by Dr. E. S. Ross.

ARGENTINA:

On artichoke (alcaucil), *Cynara scolymus,* in the provinces of Buenos Aires, Santa Fe, San Juan and other localities. (Blanchard, 1935, 366–7; 1939, pp. 945–7; 1944, p. 34).

Tribe **Nasonoviini**

Idiopterus nephrelepidis Davis

Fern Aphid

(Figure 36)

A small black and white-marked aphid with clouded wings. It feeds upon various species of ferns (*helecho, polipodio*) (Polypodiaceae) in tropical and subtropical areas.

CHILE:

A single alate specimen was taken by sweeping 40 km. east of San Carlos, Nuble Province, December 24, 1950, by Dr. A. E. Michelbacher.

ARGENTINA:

Blanchard (1939, pp. 41–42) records this species on (*Acrostichum*), *Adiantum, Nephrolepis,* and other cultivated ferns in the Province of Buenos Aires.

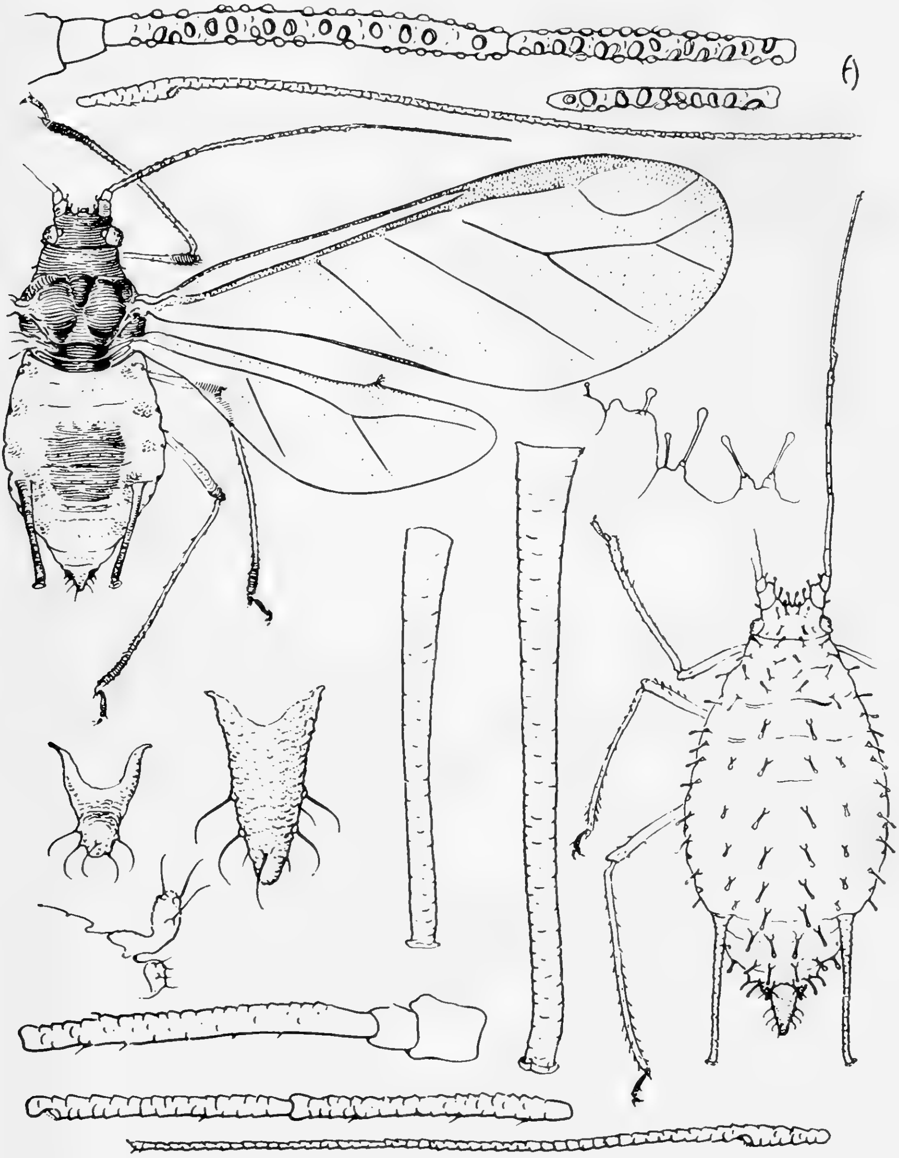


Figure 35. Artichoke aphid, *Capitophorus braggi* (Gillette). Alate and apterous parthenogenetic females with enlarged antennae, caudas, and cornicles and capitate hairs or setae on the front of the head of the aptera. Alates green and black; aptera pale green. (After Zimmerman, 1948.)

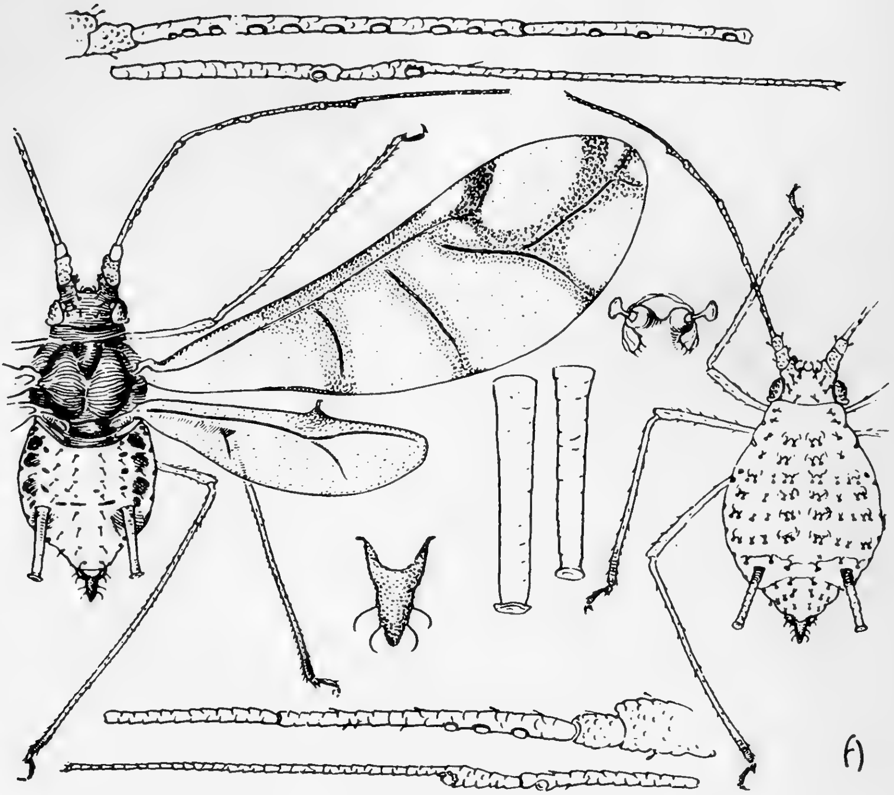


Figure 36. Fern aphid, *Idiopterus nephrelepides* Davis. Alate and apterous females; antennae and cornicles of each; cauda of alate; and body tubercle of apterous female. (After Zimmerman, 1948.)

Subfamily **DACTYNOTINAE**

Tribe **Aulacorthini**

Subtribe **Microlophiina**

Acyrthosiphon onobrychis (Boyer de Fonscolombe)[4]

Pea Aphid

(Figure 37)

---

[4] The nomenclature of this species has been the object of some concern of aphidologists. Although the above designation is now generally accepted, the eminent aphidologist D. Hille Ris Lambers (1947, p. 247), uses *Acyrthosiphon pisum* (Harris). Moses Harris (1776, pp. 66-67, pl. XIII, fig. 5), gives a brief description and a colored illustration of what is without doubt this insect, but there may be some question as to whether these constitute a valid description of a new species. This name was listed in Sherborn's "Index Animalium" (1902, p. 756), but I know of no other references to it—not even in the extensive bibliography listed by Lambers.

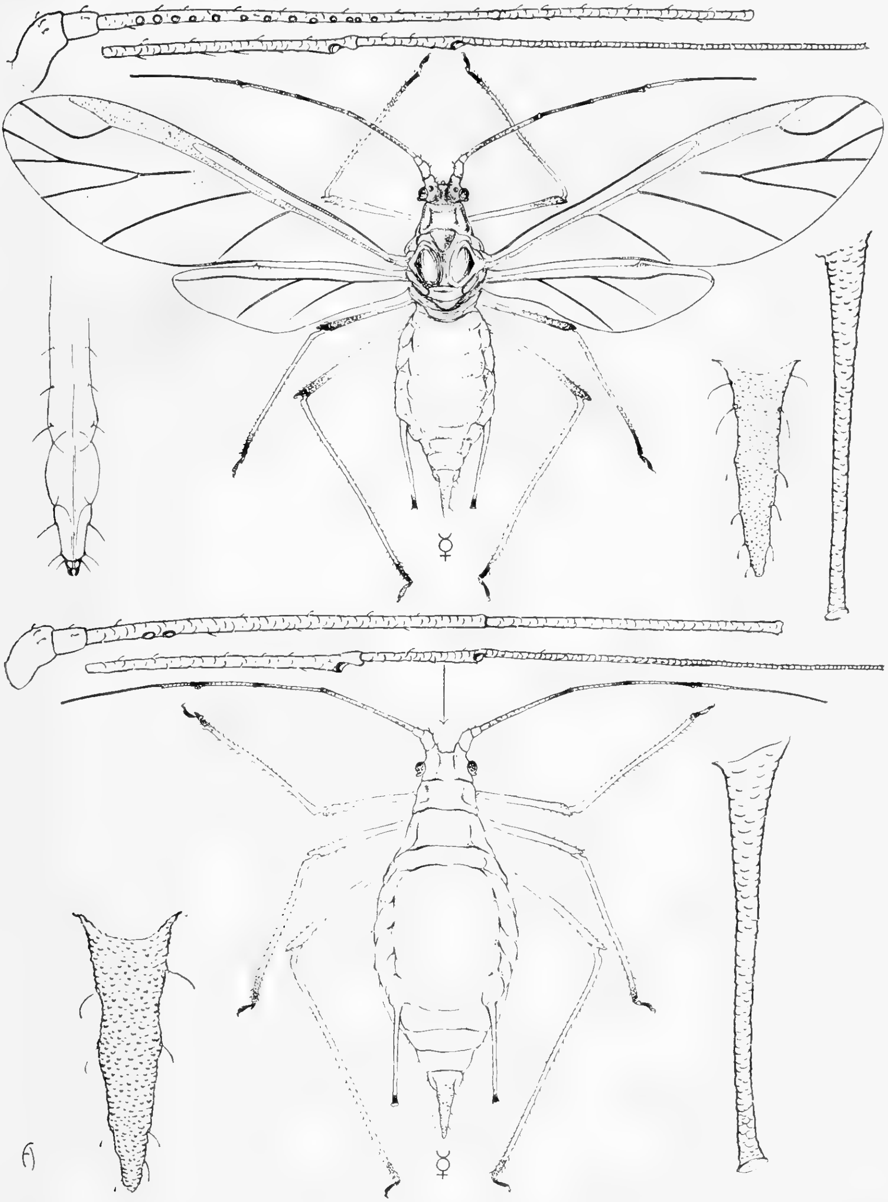


Figure 37. Pea aphid, *Acyrthosiphon onobrachis* (Fonscolombe) [*Macrosiphum pisi* (Kaltenbach)]. Alate parthenogenetic female and enlarged antenna, rostrum, cauda and cornicle at top; apterous female and cauda and cornicle at bottom. Apex of cornicle is not reticulated. Green.

Aphis pisum M. HARRIS, 1776; *A. onobrychis* BOYER DE FONSCOLOMBE, 1841; *A. lathyri* MOSLEY, 1841; *A. pisi* KALTENBACH, 1843; *Siphonophora ononis* KOCH, 1855; *Nectarophora destructor* JOHNSON, 1900; *Macrosiphum trifolii* PERGANDE, 1904; *Macrosiphum pisi* PATCH, 1911.

This large green aphid has a cosmopolitan distribution and is often a very serious pest of plants belonging to the Leguminosae. However, it does not yet appear to be widely distributed in western South America. Only one specimen was taken.

PERU:

Sweeping legumes at Mollendo, Province of Arequipa, November 19, 1950—a single apterous female.

Subtribe **Metopolophiina**

Aulacorthum pelargonii (Kaltenbach)

Geranium Aphid

Aphis pelargonii KALTENBACH, 1943; *A. malvae* WALKER, 1848–9.

This species was collected only twice as follows:

PERU:

On *geranium*, at Lima, November 15, 1950—4 apterae.

On *Solanum* sp., Callao, November 14, 1950—1 alate.

Aulacorthum pseudosolani (Theobald)

Solanum or Foxglove Aphid

(Figure 38)

Aphis solani KALTENBACH, 1843; *Macrosiphum solani* THEOBALD, 1913, *Myzus veronica* THEOBALD, 1913; *M. hydroctylei* THEOBALD, 1925; *M. pseudosolani* THEOBALD, 1926; *M. veronicellus* THEOBALD, 1926.

This aphid is widely distributed and has many host plants, but there were only two collections:

CHILE:

On a wild umbelliferous plant and by beating various plants at Purranque, Province of Osorno, January 15, 1951—1 alate and 7 apterae.

On wild potato at the same place on January 26, 1951—1 alate and 8 apterae.

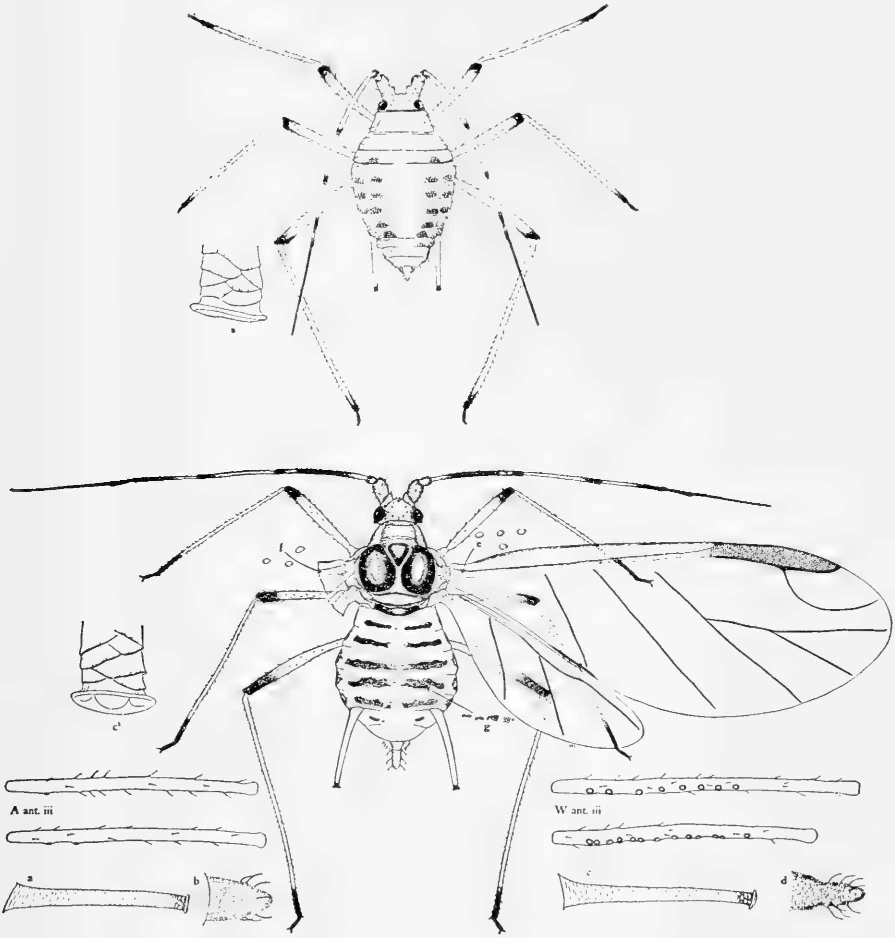


Figure 38. Solanum or foxglove aphid, *Aulacorthum pseudosolani* (Theobald) = (*Myzus solani* (Kaltenbach)). Apterous and winged parthenogenetic females with enlarged antennal segment III, cornicles and cauda. A, refers to apterous and W, for winged.

Tribe **Macrosiphonini**

Subtribe **Macrosiphonina**

Macrosiphum[5] **ambrosiae** (Thomas)

Ambrosia Aphid

(Figure 39)

Siphonophora ambrosiae Thomas, 1877.

---

[5] The spelling of the generic name *Macrosiphum* Passerini, 1860, was corrected to *Macrosiphon* to conform to the Latin word *siphon* by Del Guercio in 1913. (Redia IX, p. 187, 1913.) However, this change does not conform to the present rules and regulations of the International Committee on Zoological Nomenclature.

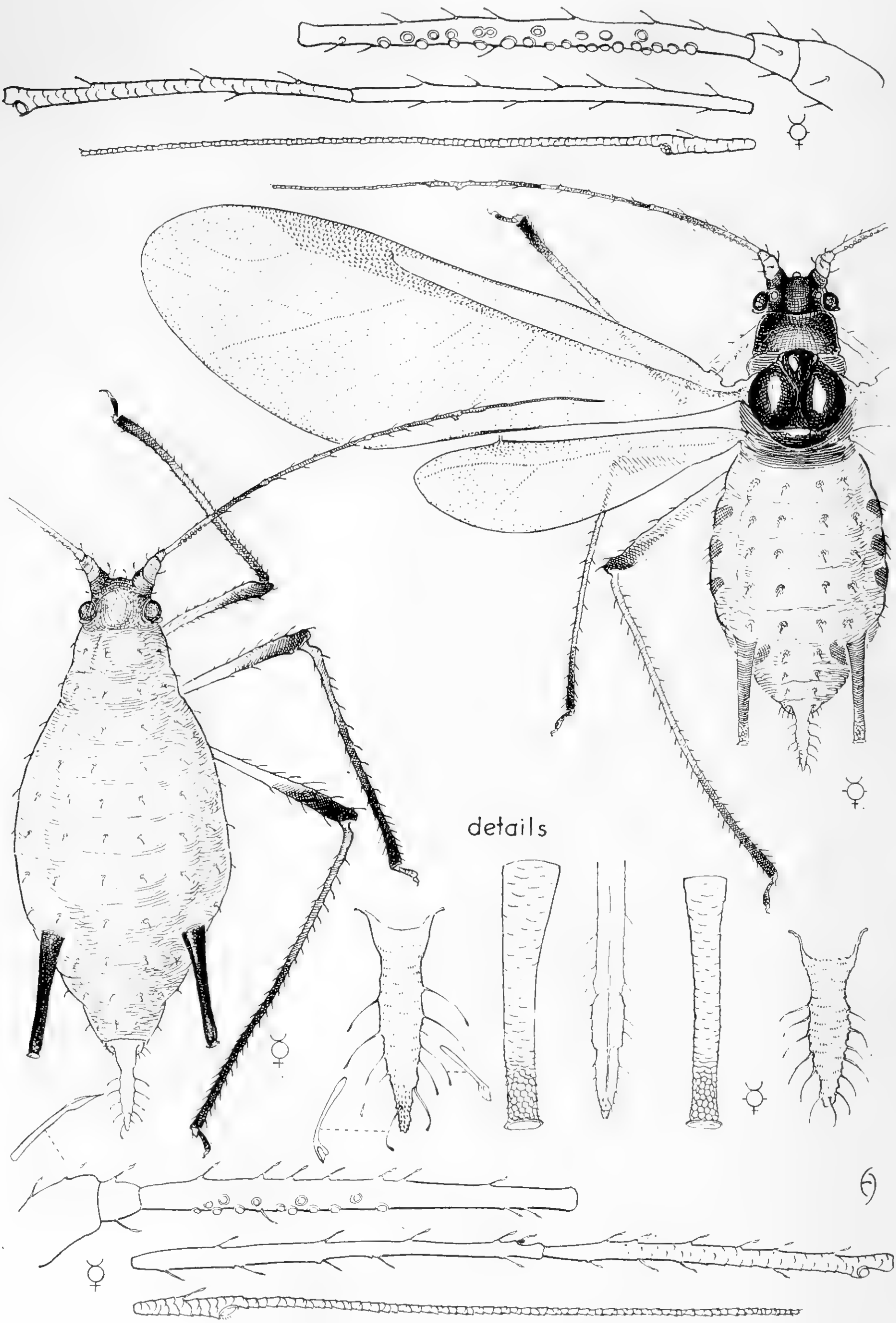


Figure 39. Ambrosia aphid, *Macrosiphum ambrosiae* (Thomas). Alate and apterous parthenogenetic females with enlarged antennae, caudas, cornicles and rostrum. Dark red and black.

This species is common and abundant in North America. It seems also to be widely distributed in South America. It is possible to confuse it with closely related species all of which form a complex that needs much investigational work.

CHILE:

On *Artemisia* sp. ?, Papudo, Province of Aconcagua, November 28, 1950—5 apterae.

On *Baccharis* sp. ?, Rivadavia, Province of Coquimbo, December 4, 1950—many apterae.

On *Baccharis* sp. ?, Junta, Province of Coquimbo, December 6, 1950—many apterae.

On *Baccharis* sp. ?, Concon, Province of Valparaiso, December 16, 1950—5 apterae.

On a grindelia-like plant, 40 km. east of San Carlos, Province of Nuble, December 23, 1950—11 apterae.

On *Baccharis* sp. ?, Tucapel, Province of Bio-Bio, December 28, 1950—22 apterae.

On *Baccharis* sp. ?, Hacienda San Andres, Purranque, Province of Llanquihue, January 15, 1951—many apterae and alatae.

On *Baccharis* sp. ?, Los Muermos, Province of Llanquihue, January 18, 1951—many alates and apterae.

Beating along the mouth of the Maullin River, Province of Llanquihue, January 22, 1951—2 alates.

ARGENTINA:

On *Artemisia* sp. ?, Salta, Province of Salta, February 14, 1951—many apterae.

On acacia-like tree (finely divided compound leaves), Salta, February 14, 1951, many specimens, all apterae.

On *Artemisia* sp. ?, Salta, February 14, 1951—6 apterae.

PERU:

On *Chrysanthemum* sp., Botanical Garden, Lima, November 13, 1950—many apterae.

On *Encelia* sp., Botanical Garden, Lima, November 13, 1950—many alatae and apterae.

On tobacco, *Nicotiana* sp., Botanical Garden, Lima, November 14, 1950—2 alatae.

On *Gerbera jamesonii,* Botanical Garden, Lima, November 14, 1950—2 alatae and 12 apterae.

On *Picris* sp. ?, Botanical Garden, Lima, November 13, 1950—many apterae.

Macrosiphum bonariensis Blanchard

Composite Aphid

This fine species was collected on *Tanacetum vulgare* L. at Flores and Lomas de Zamora, Argentina, by Blanchard (1912, pp. 205–6, fig. 10). It was raised to species status by the same author (1932, pp. 19–21, fig. 10) and more completely described by him from additional specimens collected on cultivated *Pyrethrum,* Buenos Aires; and again on *Tanacetum vulgare* L., from the Province of Buenos Aires y Cordoba, Argentina (1939, pp. 953–55).

CHILE:

A fine series of this species was collected by the Michelbachers on a member of the Family *Compositæ* near San Carlos, Province of Nuble, December 23, 1950. It appears to fall in the genus *Pharalis* Leach according to the classification by Lambers (1929).

Macrosiphum chilensis Essig, new species

Chilean Baccharis Aphid

(Figure 40)

TYPE: *Alate parthenogenetic female*: Color not indicated—possibly yellowish or greenish. Cleared specimens show the head, rostrum, and antennae; apical portions of the femora and tibiae; the cornicles, excepting the base; and portions of the cauda and caudal plates, dusky or blackish. The frontal tubercles are small. Antennae slightly longer than the body; segment I somewhat gibbous and much larger than II; III a little more than half as long as VII, with few short spine-like hairs and with 14–17 variable circular secondary sensoria distributed irregularly or almost in a straight line over the basal three-fourths of the segment; VII with short base and long, slender unguis. (In paratypes the number of sensoria on antenal segment III may vary from 13 to 20.) Rostrum extends to the second coxae. Wings as drawn. Legs rather slender. Abdomen with many very fine and a few short, stout spines, the bases of the latter surrounded by prominent dark patches somewhat like in *Macrosiphum ambrosiae* (Thomas). Cornicles cylindrical, slightly tapering; bases about twice as wide as the opening, slightly swollen anteriorly; the apical reticulated area may be slightly, but not usually, constricted; reticulations pronounced

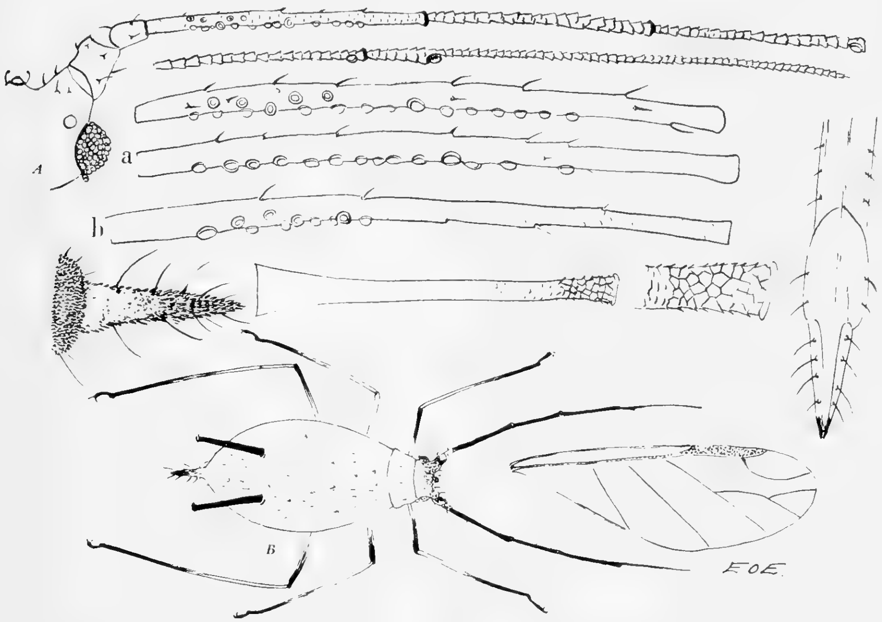


Figure 40. Chilean baccharis aphid, *Macrosiphum chilensis* Essig, new species. A, alate and B, apterous parthenogenetic genetic females; a, antennae of alate; b, antenna of aptera; cauda, cornicle, rostrum and wing of alate. Very dark.

and similar to those of *M. solanifolii* (Ashmead), but the constriction is not as noticeable; dusky except the basal one fourth. The anal plate is very small. Cauda 0.8 mm. in length and tapering as shown. Length of body 3.00 mm.; antennae 0.33 mm.; forewing 4 mm.; cornicles 0.8 mm.; cauda 0.5 mm.

Apterous parthenogenetic female: Of a uniform color and with darkened antennae, legs, rostrum, cornicles, cauda, and caudal plate and small areas at bases of thickened spines much as in the alate form. Antennal segment III has from 8–15 circular sensoria of various sizes and limited to the basal third or half of the segment—the average number is about 11 to 12. It is rarely that the same number occurs on both antennae of a given individual. Length of body 3.5 mm.; width 1.6 mm.; antennae 3.5 mm.; cornicles 0.8 mm.; cauda 0.6 mm.

This species somewhat resembles *M. solanifolii* (Ashmead) but differs in having the secondary sensoria more scattered on III in the alatae and many more on III in the apterae; and in having much darker or black antennae and cornicles.

Host plant and locality: This species was collected on *Baccharis* sp. (?), at **La Serena, Province of Coquimbo, Chile,** December 8, 1950, by Dr. A. E. Michelbacher.

In all, 4 alates, 25 apterae, and 5 immature individuals as well as one cast skin were taken. These are mounted on 5 aluminum microscope slides. The alate type is mounted on a slide with 4 mature apterous paratypes.

Macrosiphum cordobensis Blanchard

Cordobens Aphid

(Figure 41)

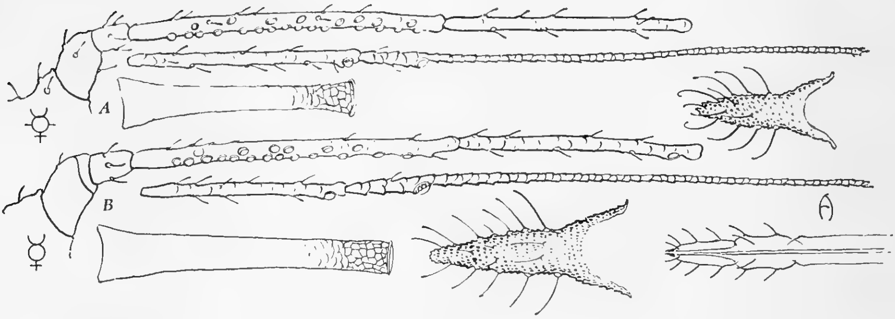


Figure 41. Cordobens aphid, *Macrosiphum cordobensis* Blanchard. Upper—A, antenna, cornicle and cauda of alate parthenogenetic female; B, antenna, cornicle cauda, and rostrum of aptera.

ARGENTINA:

On *Baccharis* sp. (?), at 4,000 feet on a ridge west of Tucuman, February 11, 1951—many apterae and alatae.

On *Erigeron* sp., Sierras de Cordobe, February 18, 1931. Original description. (Blanchard, 1932, pp. 24–36, fig. 4; 1939, pp. 963–4.)

PERU:

On potato (papa) (casual?), Sicuani, Province of Cusco, 3,000 feet—1 apterous.

Macrosiphum edrossi Essig, new species

Ross Aphid

(Figure 42)

TYPE: *Alate parthenogenetic female*: A yellowish or greenish species with the head, thorax, and all appendages brown or black. The cleared abdomen is void of any pigmented markings but has many fine hairs. The antennae are 4 mm. in length and longer than the body, slender, with short knobbed hairs, and segment III with 15–17 large and small circular secondary sensoria arranged in a row along the underside throughout the full

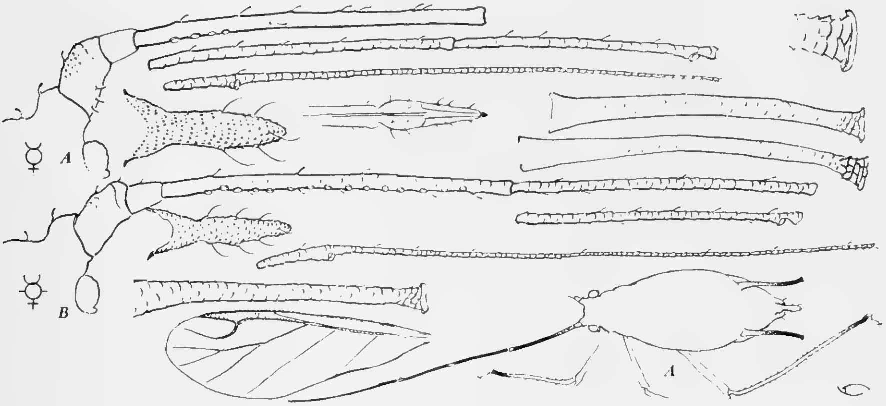


Figure 42. Ross aphid, *Macrosiphum edrossi* Essig, new species. A, antenna, cauda, rostrum and three drawings of cornicle and outline of the apterous parthenogenetic female; B, antenna, cauda, cornicle and wing of alate.

length. (In paratypes the number frequently varies for each individual as 15–17, 16–18, 15–16, etc.) The unguis of segment III is very long. The rostrum is slender, with few hairs and extends to or slightly beyond the second coxae. The legs are long and slender. The forewings are normal with venations as drawn; 4 mm. in length. The stigma is relatively long. The cornicles are black apically, long and slender, slightly curved outwardly, somewhat constricted near tips and reticulated for a very short distance at the apex where it is considerably widened. In this respect it differs from most members of the genus. The apical flaring is somewhat after the pattern of the pea aphid, *Acyrthosiphon onobrachis* (Boyer de Fonscolombe) (*Macrosiphum*), but in the pea aphid the reticulations are absent; length 0.7 mm. The cauda is rather robust, flaring at base and then slightly constricted; 0.35 mm. in length, with six hairs. The anal plate is very small and crescent-shaped. Length of body, 3 mm.

Apterous parthenogenetic female: Pale with dusky appendages and without any distinctive markings and with numerous small colorless hairs. The general characteristics are similar to those of the alate form. Antennal segment III has a variable number of basal secondary circular sensoria. This variation may best be expressed by the following examples per individual, 2–3, 3–3, 3–5, 4–2, 4–4, 5–5, 6–9, 8–5, 8–6, 8–8, etc. The cauda is more robust than that of the alate. Length of body, 2.70 mm.; antennae 2.70 mm.; cornicles 0.85 mm.; cauda 0.35 mm.

Host plant and locality: Collected on what appears to be a nettle (ortiga), *Urtica* sp., at **Rio Pampas, Peru,** March 8, 1951, by Dr. Michelbacher.

Type: An alate form mounted on a slide with 4 apterous females. The remaining 6 alates and all the 24 apterous forms are mounted on 6 other slides and are designated as paratypes.

This species differs from others in having the apices of the cornicles reticulated and flaring; an extremely long antennal filament; and only 2 or 3 pairs of hairs on the cauda.

Macrosiphum griersoni Blanchard

Grierson Aphid

Argentina:

This species was described by Blanchard (1932, pp. 27–29, fig. 5) from the artichoke (alcachofa, arcacil, aguaturma), *Cynara scolymus* L., Jujuy and Buenos Aires, in 1924, and on *Vernonia* sp., Sierra de Cordoba.

Chile:

A single alate specimen of what appears to be this species was collected by the Michelbachers on a composite, San Carlos, Province of Nuble, December 23, 1950.

An adult alate collected by sweeping at Angol, Province of Malleco, January 29, 1951.

Macrosiphum huantana Essig, new species

Huanta Aphid

(Figure 43)

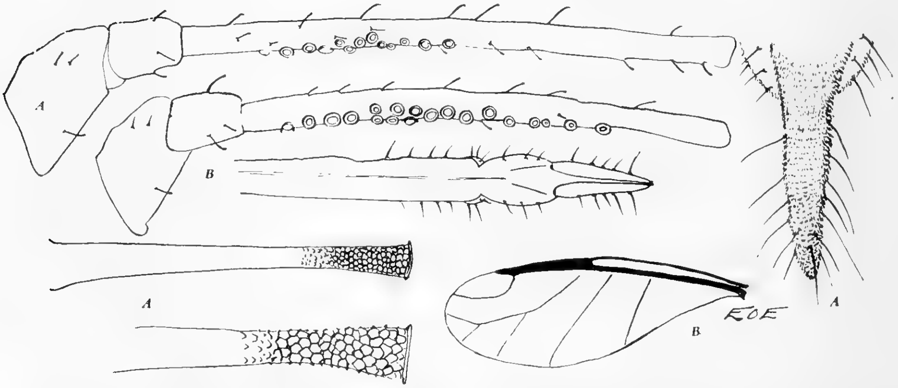


Figure 43. Huanta aphid, *Macrosiphum huantana* Essig, new species. A, antenna, cornicles, and cauda of the apterous parthenogenetic female; B, antenna, rostrum and wing of alate.

Type: *Alate parthenogenetic female*: A dark species remaining brownish when cleared and mounted; without definite pigmented areas, but with the appendages dark brown. Antennae slender with few blunt or knobbed hairs: secondary sensoria on segment III variable in size and scattered over the basal half or two thirds; varying in number from 17 to 19. (In paratypes they vary in number after this pattern: 13–13, 17–19, 17–19, in the three alates available.) They are longer than the body, 4.20 mm. Rostrum long and slender with many small hairs or spines; extending to the third coxae. Wings 4 mm. long; clear; venation as drawn. Legs slender. Cornicles dark, long and cylindrical; widening basally and apically; apical one-fourth reticulated; length 0.75 mm. Cauda brownish, long, slender, gradually tapering posteriorly; 12–14 hairs present; 0.40 mm. long. Anal plate rounded, twice the width of the base of the cauda, with many long spines.

Apterous parthenogenetic female: Dark in color with all appendages brownish in cleared specimens; without definite pigmented areas. Secondary sensoria on antennal segment III variable in size and number; usually limited to the basal half of the segment; ranging in number from 8 to 16 after the pattern: 7–8, 7–9, 10–10, 12–12, 12–15, 16–16. Length of body 3.50 mm.; antennae 4.50 mm.; cornicle 0.80 mm.

Host plant and locality: Collected on *Baccharis* sp. along the Rio Turbio, branch of the Rio Elqui **five miles south of Huanta** (Guanta), **Province of Coquimbo, Chile,** December 7, 1950, by Dr. A. E. Michelbacher.

This species is close to *M. littoralis* Blanchard, but has more sensoria and hairs on rostrum and cauda and cornicles flaring at apices.

This species also differs from other related species in having the extremely long cauda and the long, slender rostrum.

Altogether 30 specimens were taken: 3 alatae and 27 apterae. The type specimen is an alate mounted on a slide along with another alate and three adult apterae paratypes. All other specimens are also designated as paratypes.

Macrosiphum lizerianum Blanchard

Lizer Aphid

A single apterous female of what appears to be this aphid was taken by sweeping.

Chile:

At Zapallar, Province of Aconcagua, November 27, 1950.

Argentina:

Blanchard (1922, pp. 185–7, fig. 1) collected this aphid on *Sonchus* sp., *Cosmos* sp., *Aster* sp., *Wedelia glauca,* and species of *Composite* at Punta Chica, San Isidro, Flores and Cañuelas, Province of Buenos Aires, and at Potrerillos and Cachueta, Province of Mendoza. He states it is close to *M. solidaginis* (Fabricius).

Macrosiphum macolai Blanchard

Macola Aphid

(Figure 44)

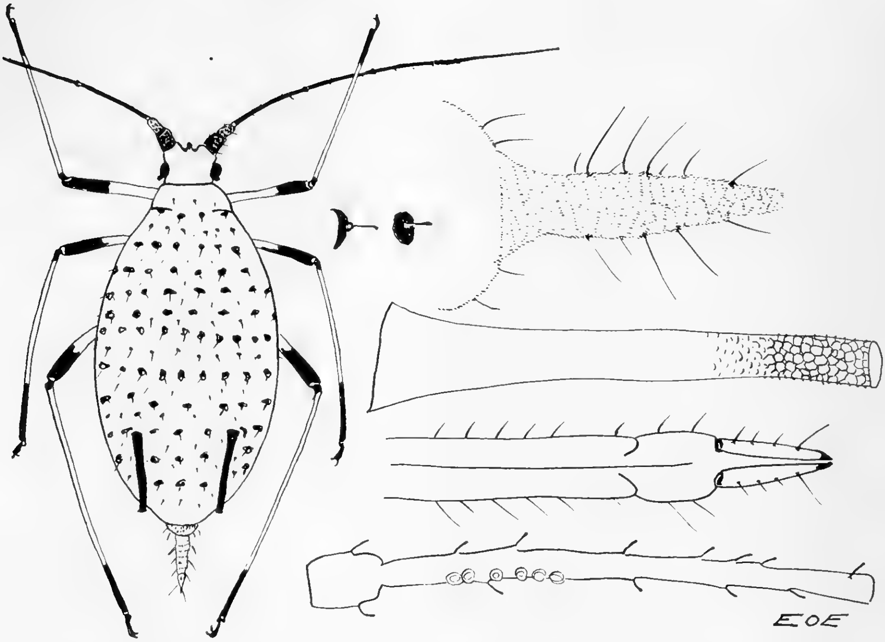


Figure 44. Macaloi aphid, *Macrosiphum macaloi* Blanchard. Apterous parthenogenetic female showing small knobbed setae arising from dark areas on the dorsum of the abdomen; cauda; cornicle; rostrum; and antennal segment III.

ARGENTINA:

On *Baccharis salicifolia* Mendoza, June 10, 1926. (Blanchard 1936, pp. 29–30, fig. 6. Original description: 1939, 966–7.)

On *Erigeron* sp. (chilca), Province of Mendoza, by Blanchard (1944, p. 42).

CHILE:

On the common dandelion, *Taraxicum vulgare*, at El Abanico, Province of Bio-Bio, December 30, 1950—1 aptera.

On *Baccharis* sp. ?, at Negrete, Province of Bio-Bio, January 30, 1951—27 apterae.

Macrosiphum muermosa Essig, new species

Muermos Aphid

(Figure 45)

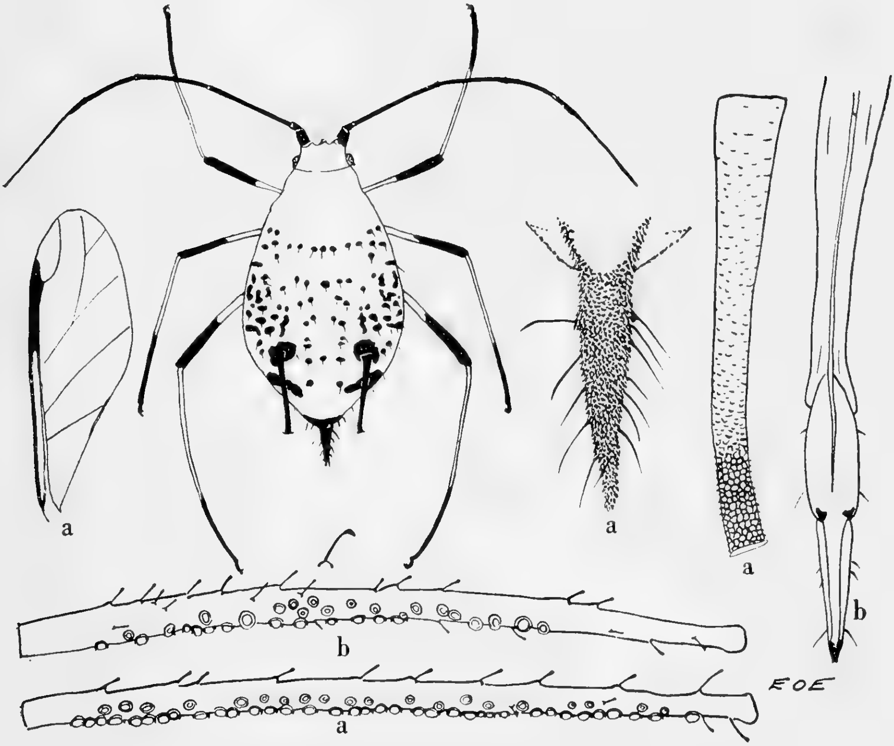


Figure 45. Muermos aphid, *Macrosiphum muermosa* Essig, new species. Apterous parthenogenetic female showing typical color pattern; a, wing, cauda, cornicle, and antennal segment III of alate; b, rostrum and antennal segment III of apterous female.

TYPE: *Alate parthenogenetic female*: Probably deep red, brown, and black—the alcoholic preserving fluid material was stained a very deep reddish-brown color. Cleared specimens appear black, dark brown, and transparently colorless. The spines are short and knobbed. The antennae are curved; approximately the length of the body and extending to the tip of the cauda; dark to black in color; secondary sensoria only on segment III, circular to oval, rather small, quite variable in size, 43–44 in number and distributed throughout the full length, except the base and extremity; spines, short, curved, slightly knobbed. (Paratypes show a variation of from 39–49 sensoria on antennal segment III.) Rostrum slender with narrow apical segments; extends to or nearly to the third coxae; with few inconspicuous hairs. Legs slender; hind tibiae strongly curved; tarsi very small. Cornicles black; wider at base, nearly cylindrical, slightly curved outwardly; apical one fourth plainly reticulated; 1 mm. in length. Cauda black, long, and well developed; with many hairs; 0.5 to 0.7 mm. long. Anal plate small and crescent shaped; with few rather long hairs.

Length of body 4 mm.; antennae 4.2 mm.; forewing 4 mm.; cornicles 0.75 mm.; cauda 0.50 mm.

Apterous parthenogenetic females: Dark reddish and black with the abdomen adorned with black, irregular markings. The antennae are slender, slightly longer than the body and curved. The spines are short, somewhat curved or straight and terminate in a knob or slightly enlarged. The sensoria on antennal segment III are quite variable in size, extend over much of the length as drawn, and range in numbers after the following pattern: 22–25, 25–30, 26–33, 29–29, 32–34, 36–36, etc. Other characters are similar to those in the alate. Length of body 4.5 mm.; antennae 4.2 mm.; cornicles 1 mm.; cauda 0.75 mm.

This species belongs to the group of dark-colored aphids which have short, stiff, spine-like hairs; long, slender, curving antennae; slender rostra; many variable secondary sensoria only on antennal segment III of both alate and apterous forms; and black pigmentation on the intersegmented, marginal, antesiphunucular, and other areas of the abdomen such as occur in *Macrosiphum ambrosiae* (Thomas), *Dactynotus picridis* (Fabricius), *D. taraxaci* (Kaltenbach) and many other related species.

Host plant and locality: Taken on a "yellow composite with long lance-like leaves, light pubescence on the undersurfaces giving silver color," at **Los Muermos, Province of Llanquihue, Chile,** by Dr. A. E. Michelbacher. Many specimens of both alate and apterous forms are mounted on 13 slides.

A single alate specimen, on a slide with two apterous females, has been designated as the type; all others as paratypes.

This species resembles somewhat *M. lizerianum* Blanchard, but differs in being larger; darker; with many more sensoria on antennal segment III in both alate and apterous forms, with a wide distribution of sensoria in the aptera; the slender cauda; and long, slender rostrum.

Macrosiphum nuble Essig, new species

Nuble Aphid

(Figure 46)

TYPE: *Apterous parthenogenetic female*: Color generally pale green (?); head, rostrum, antennae, most of the legs, cornicles, excepting the basal portions, cauda, dark or brownish. There are no body markings on the apterous form described but it is beset with rows of short spines arising from basal cones and curved (drooping) and knobbed. The antennae are long and slender with 13 to 16 small circular secondary sensoria irregularly arranged on the ventral basal fourth or third of the segment. (In paratypes the ratio on 4 specimens is 7–9, 9–13, 12–15, 13–15.) The

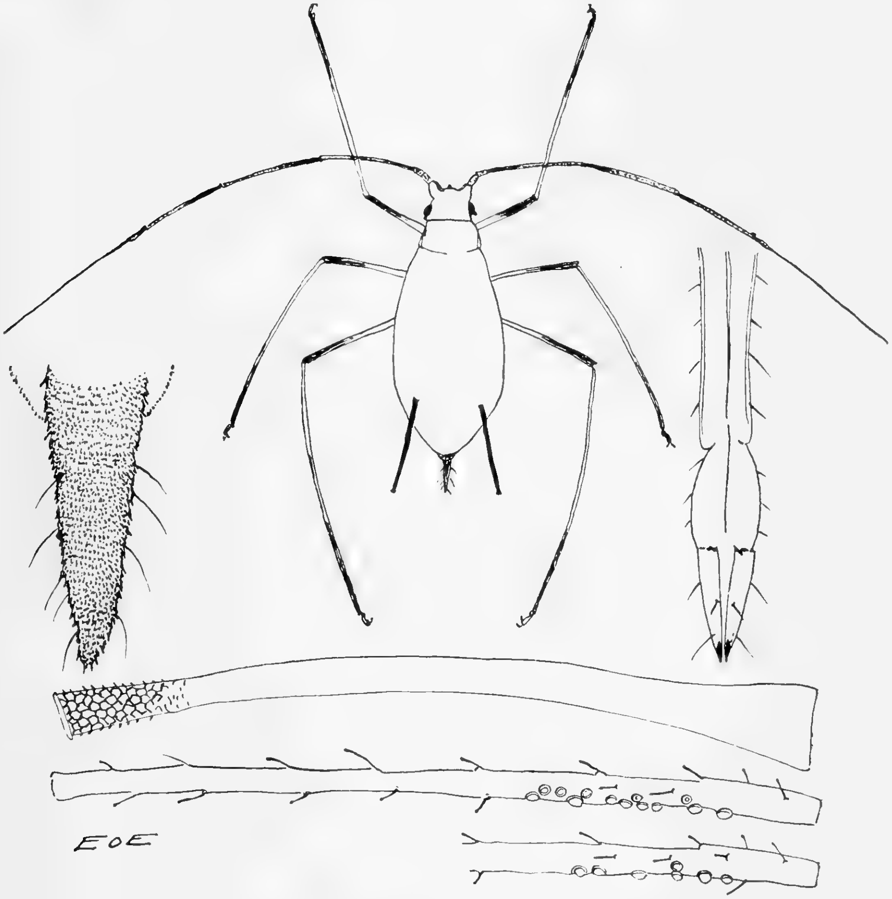


Figure 46. Nuble aphid, *Macrosiphum nuble* Essig, new species. Apterous parthenogenetic female and enlarged cauda, cornicle, rostrum and antennal segment III showing sensoria.

rostrum is short, reaching to the third coxae. The proportions of the various segments and the spination are illustrated. The cornicles are unusually long, 0.80 mm.; curved outwardly; cylindrical or slightly swollen, and reticulated, but not constricted apically. The cauda is relatively short, 0.30 mm., rather thick and with many spines. The anal plate is very small and semioval. Length of body 3.30 mm.

Host plant and locality: The species was collected on a composite plant in the Andes Mountains **near Fabian, Province of Nuble, Chile,** December 15, 1950, by Dr. A. E. Michelbacher.

The specimens consist of seven apterous females which are mounted on three slides. One individual is indicated as the type. All the others are designated as paratypes. No alates were collected.

This species resembles *Macrosiphum solanifolii* (Ashmead) in having the short rostrum and the apically reticulated cornicles, but differs in having a much larger number of secondary sensoria in the apterae which are irregularly arranged on the base of antennal segment III; by the much longer cornicles; by the more attenuated rostral apex; and the shorter, thicker cauda.

Macrosiphum rosae (Linnaeus)

Rose Aphid

(Figure 47)

Aphis rosae LINNAEUS, 1758; *A. scabiosae* SCOPOLI, 1763; *A. dipsaci* SCHRANK, 1801; *Siphonophora rosaecola* PASSERINI, 1871; *Nectarophora valerianiae* CLARKE, 1903; *Macrosiphum centranthi* THEOBALD, 1915; *Macrosiphon rosae* (Linnaeus) BÖRNER, 1952.

The rose aphid is almost a cosmopolitan species being widely distributed through commerce. It occurs usually on wild and cultivated roses and temporarily infests such other plants as *Camellia japonica, Dipsacus fullonum, D. sylvestris, Rudbeckia hirta,* and *Sonchus* spp. It is now well distributed in parts of South America.

CHILE:

On cultivated rose, Valparaiso, November 26, 1950—1 alate and 6 apterae.

On *Sonchus,* sp., Valparaiso, November 26, 1950—1 alate and 17 apterae.

On cultivated rose, Vicuna, Province of Coquimbo, December 4, 1950—apterae and alatae.

On beans, *Phaseolus* sp., San Carlos, Province of Nuble, December 23, 1950—1 alate—casual ?.

On rose, Temuco, Province of Cautin, January 6, 1951—apterae and alatae.

Sweeping peafield, Lautaro, Province of Cautin, January 6, 1951—1 apterae and 1 alate.

On *Sonchus* sp., Rio Bueno, Province of Valdivia, January 14, 1951—1 apterous.

PERU:

On cultivated rose, Lima, July 15, 1937. Collected by Mrs. Selma Gahl—1 alate and 4 apterae. In author's collection.

On cultivated rose, Botanical Garden, Lima, November 13, 1950—abundant; many apterae and 1 alate.

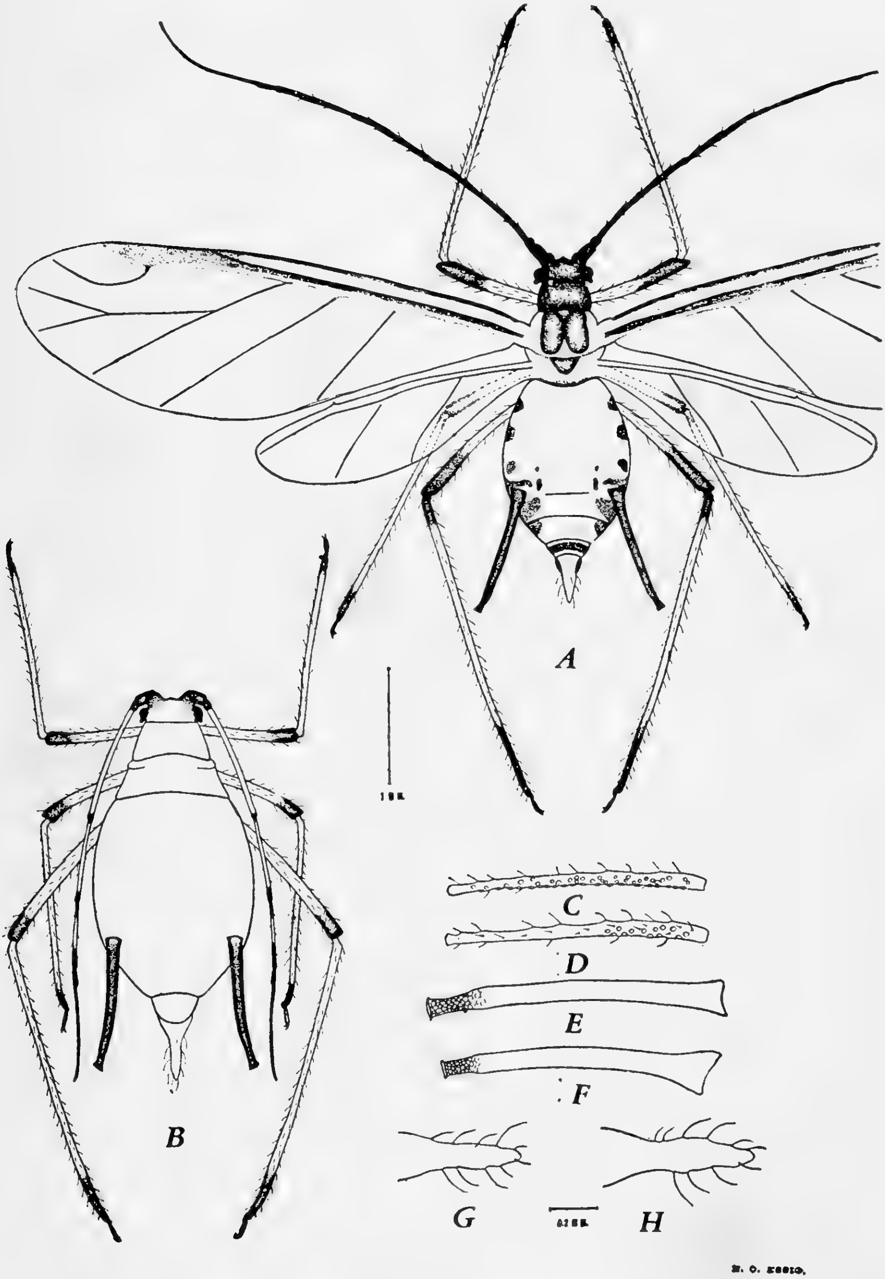


Figure 47. Rose aphid, *Macrosiphum rosae* (Linnaeus). A, alate parthenogenetic female; B, apterous female; C, antennal segment III of alate showing sensoria; D, antennal segment III of aptera; E, cornicle of alate; F, cornicle of aptera; G, cauda of alate; H, cauda of aptera.

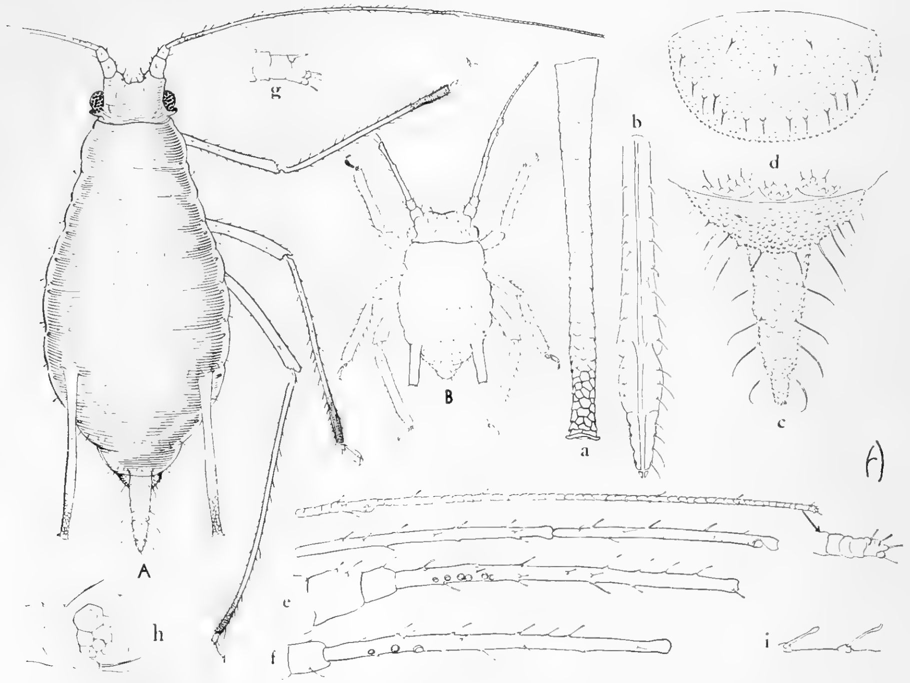


Figure 48. Potato aphid, *Macrosiphum solanifolii* (Ashmead). A, apterous parthenogenetic female with enlarged: a, cornicle; b, dorsum of rostrum; c, cauda; e, antenna; f, another antennal segment III. B, first instar young; g, tip of the antenna of same; h, sensoria in the process on antennal segment VI of embryo; i, enlarged antennal setae.

On cultivated rose, Chiclayo, Province of Lima, March 21, 1951—many specimens; all apterae.

Argentina:

Common on cultivated roses throughout Argentina and also on loquat (nispero) *Eriobotrya japonica*. (Blanchard 1922, pp. 187–190, fig. 2; 1939, pp. 967–9).

Macrosiphum solanifolii (Ashmead)

Potato Aphid

(Figures 48–49)

Siphonophora solanifolii Ashmead, 1882; *S. euphorbiae* Thomas, 1878; *Macrosiphum cucurbitae* del Guercio, 1913; *Macrosiphum gei* (Koch) Hottes and Frison, 1931; *Macrosiphon solanifolii* (Ashmead) Börner, 1952.

This is a very widely distributed Holarctic species and appears to

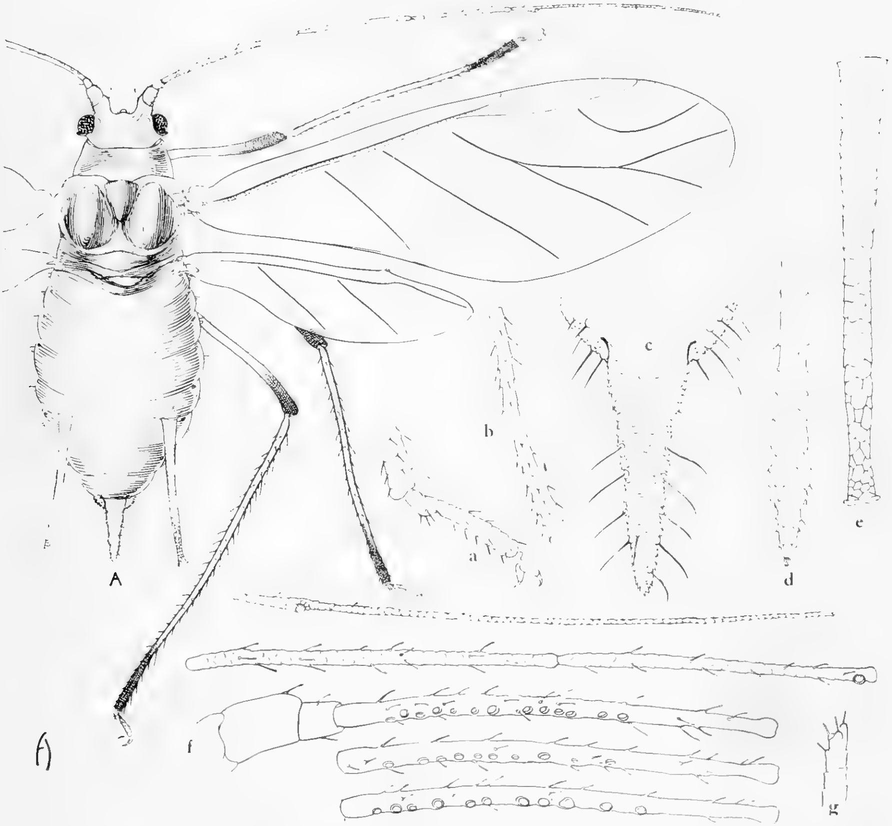


Figure 49. Potato aphid, *Macrosiphum solanifolii* (Ashmead). A, alate parthenogenetic female; a, hind tarsus; b, upper and lower portions of the hind tibia; c, cauda; d, rostrum—ventral aspect; e, cornicle; f, antenna with two additional segments of segment III from other individuals to show variation; g, tip of antenna.

be well represented in South America. The extensive collections help to substantiate this belief.

CHILE:

On squash, *Cucurbita maxima*, Antofagasta, November 21, 1950—abundant; apterae and alate.

On *Sonchus* sp., Zapallar, Province of Aconcagua, November 27, 1950 1 alate.

On *Cereus* cactus, Las Palmas, Province of Aconcagua, November 29, 1950—apterous.

On beans, *Phaseolus* sp., San Carlos, Province of Nuble, December 23, 1950—1 alate.

On artichoke, *Cynara scolymus,* San Carlos, Province of Nuble, December 23, 1950—2 alatae.

On anise, or dill, *Anethum graveolens,* Angol, Province of Bio-Bio, January 1, 1951—1 alate.

On morning glory, *Convolvulus* sp., Angol, January 1, 1951—many apterae and alatae.

On cultivated tomato (tomatera), *Lycopersicon esculentum,* Angol, January 2, 1951—1 alate.

On squash, *Cucurbita maxima,* Agricultural School, Angol, January 4, 1951—many apterae and alatae.

On cultivated potato (patata, papa), *Solanum tuberosum,* Angol, January 5, 1951—1 alate and 5 apterae.

On garden pea, *Lathyrus sativus* L., by sweeping, Lautaro, Province of Cautin, January 6, 1951—1 aptera and 1 alatae.

Sweeping at Los Muermos, Province of Llanquihue, January 20, 1951 1 alate.

On wild potato, Puyehue, Province of Osorno, January 26, 1951—1 apterous and 4 alatae.

ARGENTINA:

Blanchard (1922, pp. 190-2, fig. 3; 1939, pp. 969–70; 1944, p. 43) lists the species on many host plants, including:

Antirrhinum sp., (cardos), *Carduus* sp., *Citrus* sp., *Cosmos* sp., *Cristaria corchorifolia* Gris., *Curcurbita* spp., *Ipomœa batatas* (L.), *Lactuca* sp., *Malva* sp., *Pyrus communis* L., *P. malus* L., *Prunus avium* L., *Solanum lycopersicum* L., *S. tuberosum* L., *Spinacia oleracea* L., *Vicia faba* L., and *Watsonia* sp.

The writer has recently received specimens from L. A. Bahamondes, collected by him

On *Tulipa* sp. at Mendoza, October 13, 1950—1 aptera and 1 alate.

COLOMBIA:

On *Lantana* sp., at the port of Buenaventura, November 3, 1950—many specimens of apterae and alatae.

PERU:

On bean, *Phaseolus vulgaris* L., at Callao, November 14, 1950—1 alate and many apterae.

On marigold, *Calendula officinalis,* Callao, November 14, 1950—1 alate and many apterae.

On marigold, *Calendula officinalis,* Callao, November 14, 1950—1 alate and a number of apterae.

On pomegranate, *Punica granatum* L., Callao, November 14, 1950—10 apterae.

On marguerite, *Chrysanthemum frutescens,* Callao, November 14, 1950—many apterae.

On *Datura* sp., Botanical Garden, Lima, November 14, 1950—2 alatae and 10 apterae.

On mallow, *Malva* sp., Callao, November 14, 1950—1 alate and many apterae.

On tobacco, *Nicotiana* sp., Botanical Garden, Lima, November 14, 1950—5 alates.

On *Solanum* sp., Callao, November 14, 1950—2 alates and many apterae.

On potato, *Solanum tuberosum,* Callao, November 16, 1950—5 alatae and 8 apterae.

On cotton, *Gossypium* sp., Chanca, Province of Lima, March 15, 1951 1 apterous.

On *Asclepias* sp., and on thorny shrub (Leguminosae) at Chiclayo, Province of Lima, March 19, 1951—all apterae.

Macrosiphum tucumani Essig, new species

Tucuman Aphid

(Figure 50)

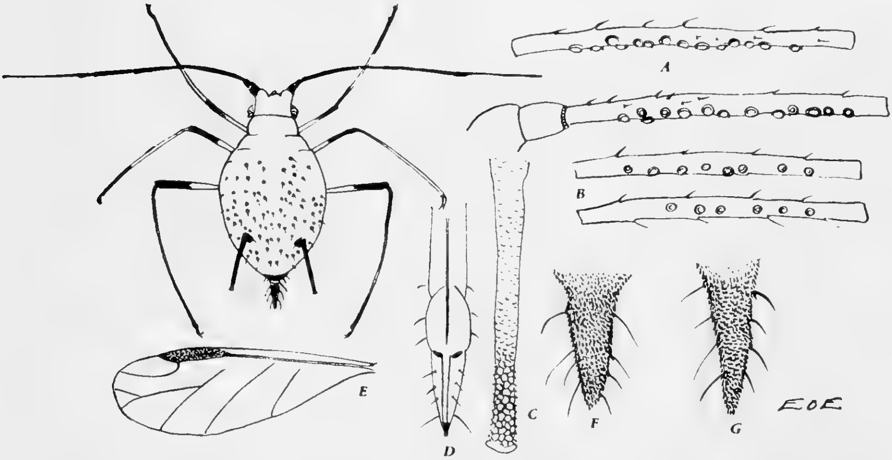


Figure 50. Tucuman aphid, *Macrosiphum tucumani* Essig, new species. Apterous parthenogenetic female showing general color pattern; A, two antennal segment III of the alate; B, same for the aptera; C, cornicle of alate; D, rostrum of alate; E, wing; F, cauda of alate; G, cauda of aptera.

TYPE: *Alate parthenogenetic female*: The color is apparently nearly black in the living forms and retains much of the same when cleared and mounted. A relatively small species averaging 2 mm. in length. The body spines or hairs are short and mostly knobbed or enlarged apically. The antennae are black; long and slender; longer than the body; 2:20 mm. The unguis or filament is about six times the length of the base. Segment III has the following distribution of secondary circular sensoria arranged nearly in a row: 14–14. (In paratypes the following variation was noted: 13–15, 15–16 on the other six alates collected.) The rostrum is of even width to the pointed apical segment and extends to or just beyond the third coxae. The legs are mostly black, slender, and the tibiae curved as shown. The wings are as drawn and are 2.70 mm. in length. The second branch of the media is two-thirds beyond the base. The cornicles are nearly cylindrical, black or somewhat paler basally with the apical one-fourth reticulated; length 0.47 mm. The base and apex are somewhat wider than the rest. The cauda is not quite half of the length of the cornicles or 0.22 mm. and has 8 or 9 spine-like hairs.

Apterous parthenogenetic female: Dark, body is covered with very many small blackish areas around the bases of the short knobbed spines as is a characteristic of such species as *Macrosiphon ambrosiae* (Thomas), *Dactynotus jaceae* Linnaeus, *D. picridis* (Fabricius), *D. taraxaci* (Kaltenbach), and others. Antennal segment III has circular secondary sensoria loosely distributed almost the full length in the following combinations: 7–8, 7–12, 9–9, 9–10, 11–13, 12–12. The cornicles are somewhat longer than in the alate, being 0.50 mm. Length, 2 mm.

Host plant and locality: On *Baccharis* sp. at **Huanta** (Guanta) on the Rio Turbia which flows into the Rio Elqui, **Province of Coquimbo, Chile,** December 4, 1950, by Dr. A. E. Michelbacher; and on *Baccharis* sp. (?), on a ridge at 4,000 feet altitude, 24 kilometers west of **Tucuman, Argentina,** February 11, 1951, by Dr. Michelbacher. The collections consisted of 43 adult and a number of immature apterous forms, and 7 alates. One of these, mounted on a slide with a number of alates and immature forms has been designated as the type. All others are labeled paratypes.

This species is unusual in having a relatively short cauda and somewhat blunter rostrum. The cornicles somewhat resemble those of *M. solanifolii* (Ashmead) in the arrangement and amount of reticulation, but number and distribution of sensoria are quite different, especially the greater number on III of the apterae as figured.

Tribe **Dactynotini**

Subtribe **Dactynotina**

Amphorophora peruviana Essig, new species

Peruvian Aphid

(Figure 51)

Type: *Alate parthenogenetic female*: A pale and dark species with dusky-bordered wing veins. The body, excepting the abdomen, is mostly dark; the abdomen has a few regular dark patches similar to those shown in the drawing of the apterous form. The antennae are slender, longer than the body—the unguis is about six times the length of the base. Circular secondary sensoria of various sizes occur nearly in a row on the underside of segment III. The number may vary from 14 to 15. (In paratypes there is a variation in the number of 14–19.) The rostrum is relatively short and extends only to the third coxae; with many short spines as illustrated. The forewings are as drawn. The legs are slender. The cornicles are about twice as long as the cauda and are smooth, distinctly swollen, with two or three rings or broken reticulations at the apex, the flange is irregularly flaring, 0.55 mm. long. The cauda is triangular, being more pointed in the alate than in the apterae; 0.30 mm. long and 0.14 mm. to 0.17 mm. wide at the base and with the normal number of hairs. Length of body 3.50 mm.; length of forewing 3.50 mm.

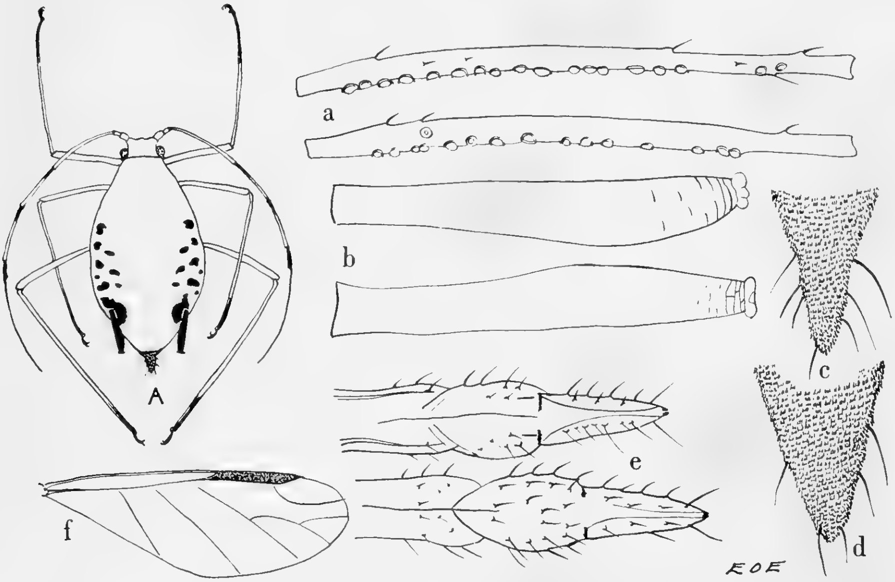


Figure 51. Peruvian aphid, *Amphorophora peruviana* Essig, new species. A, aptera showing color pattern; a, antennal segment III of alate above and aptera below; b, cornicles; c, cauda of alate; d, cauda of aptera; e, rostrum upper and lower surfaces; f, wing.

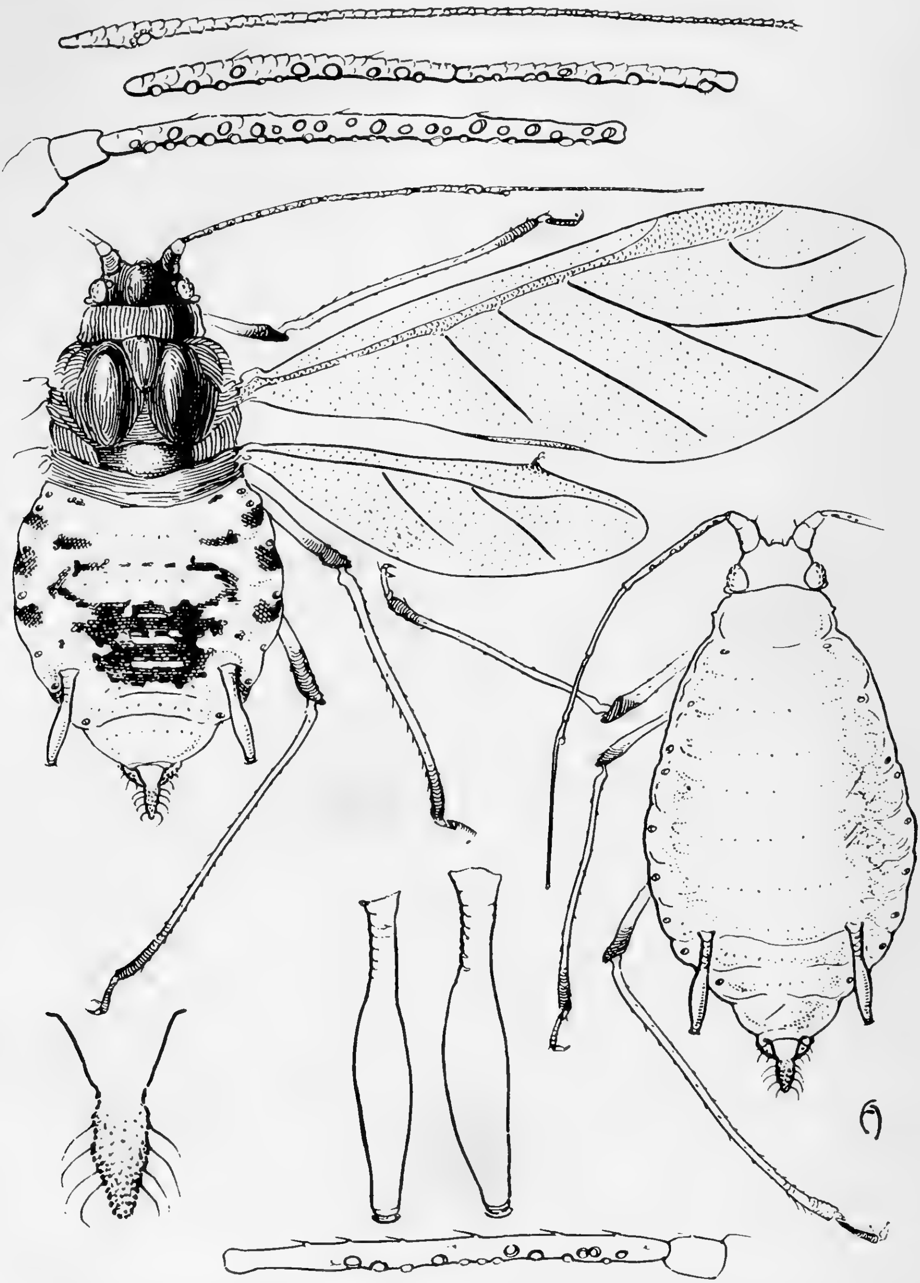


Figure 52. Sow-thistle aphid, *Amphorophora sonchi* (Oestlund). Alate and apterous forms with enlargements of antenna of alate, and antennal segment III of the apterous; cornicles of both, and cauda of alate. (After Zimmerman, 1948.)

Apterous parthenogenetic female: Normal in size and form, 3 mm. in length. The general characteristics similar to those of the alate. Antennae without secondary sensoria. Cauda broader than in the alate, with few spines.

The type specimen was chosen from three alates (one designated as the type) and five mature apterae and one immature specimen. All mounted on four aluminum slides.

The type is mounted singly on a slide. The remaining alatae and all apterae are designated as paratypes.

Host: Unknown; specimens were obtained by beating onto a canvas sheet.

Locality: **Rio Pampas, Peru,** March 8, 1951.

Collector: Dr. A. E. Michelbacher.

This species somewhat resembles *A. sonchi* (Oestlund) but differs markedly in having much shorter and more triangular cauda; thickened cornicular openings; hairy rostrum; and dark body markings.

Amphorophora sonchi (Oestlund)

Sow-thistle Aphid

(Figure 52)

Rhopalosiphum sonchi Oestlund, 1886; *Amphorophora cosmopolitana* Mason, 1925.

This is a large green and black species which, in colder areas of its range, overwinters on *Ribes* spp., and passes the summer on *Sonchus* spp., and other related hosts. In the warmer areas it may pass both winter and summer on the latter.

Chile:

On *Sonchus* sp., Zapallar, Province of Aconcagua, November 27, 1950—many apterae.

On *Sonchus* sp., Rio Bueno, Province of Valdivia, January 14, 1951—a number of apterae.

Argentina:

On *Sonchus* sp., in Province of Buenos Aires. Listed as *Amphorophora lactucae* (Kaltenbach) Blanchard (1922, pp. 207–9, fig. 11).

On *Lactuca* spp., *Sonchus* spp., and *Cichorium endivia* in Province of Buenos Aires. Listed as *Amphorophora cosmopolitanus* Mason (Blanchard, 1939, pp. 951–53).

Figure 53. Woolly apple aphid, *Eriosoma lanigera* (Hausmann), as it appears on apple.

Family **ERIOSOMATIDAE**

Subfamily **ERIOSOMATINAE**

Tribe **Eriosomatini**

Eriosoma lanigera (Hausmann)

Woolly Apple Aphid

(Figures 53–54)

Aphis lanigera Hausmann, 1802; *Coccus mali* Bingley, 1803; *Myzoxylus mali* Blot, 1831; *Eriosoma mali* Samouelle, 1819; *Schiozoneura lanigera* Hausmann, 1841.

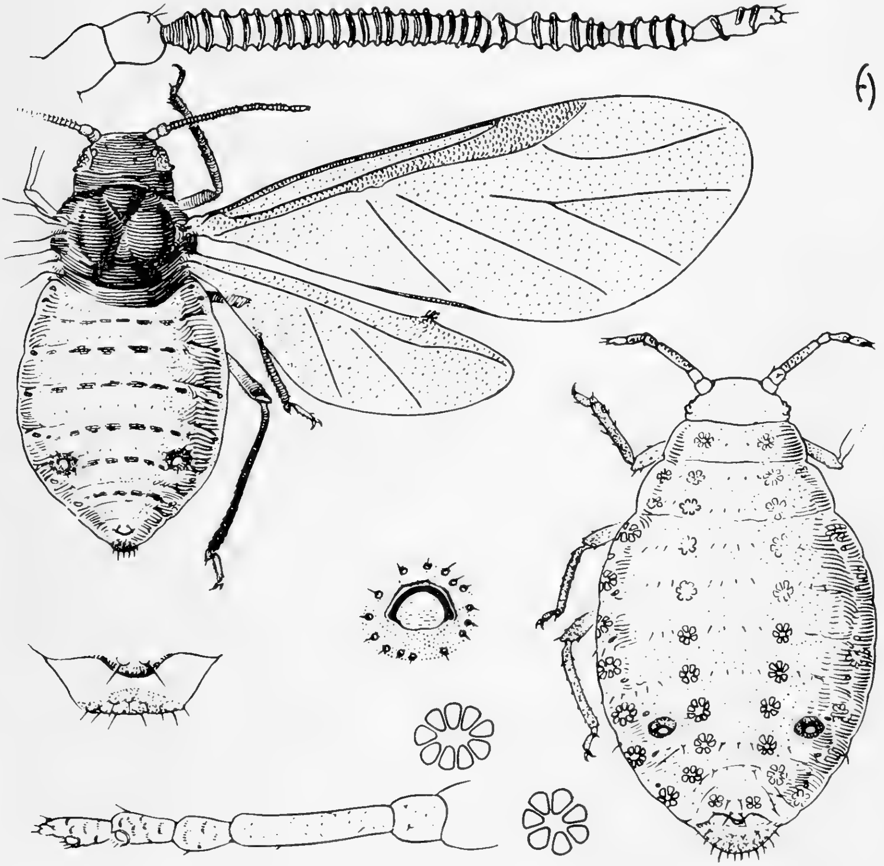


Figure 54. Woolly apple aphid, *Eriosoma lanigera* (Hausmann). Alate and apterous parthenogenetic females x 66; antennae of alate and aptera; cauda and anal plate and cornicle of alate; wax glands of aptera x 166. (After Zimmerman, 1948.)

This is a Holarctic species now common throughout temperate Europe and North America. It has been widely distributed through commerce to all temperate regions where its hosts flourish.

Chile:

On cultivated apple (manzano), Anglo, Province of Bio-Bio, January 1, 1951; only apterae were taken. The material showed about 20 per cent parasitism by *Aphelinus mali* (Haldeman) which was introduced into Chile many years ago.

Argentina:

According to Blanchard (1926, pp. 333–35; 1939, pp. 983–84), the woolly apple aphid is common on apple wherever grown. He also states that the "introduction of *Aphelinus mali* Haldeman has done much to keep it in control."

Subfamily **PEMPHIGINAE**

Tribe **Pemphigini**

Pemphigus populi-transversus Riley

Transverse Poplar Gall Aphid

(Figure 55)

Peru:

What is believed to be this species was collected by Dr. A. E. Michelbacher on the roots of plants exposed by turning stones in the bed of the Red River, Callao, November 16, 1950. The lot consisted of 7 apterae and 15 alates.

Argentina:

Blanchard (1926, pp. 335–337; 1939, pp. 986–87) records this species as forming subglobular galls on the leaf petioles of *Populus canadensis* which may have been introduced into the Province of Buenos Aires. Also on *Populus angulata* Ait.

Thecabius populi-monilis (Riley)

Bead-like Cottonwood Gall Aphid

(Figure 56)

Pemphigus populi-monilis Riley, 1879; *Thecabius populimonilis* (Riley) Gillette, 1913.

Chile:

This aphid makes elongated marginal galls in rows along the veins of

Figure 55. Galls of the transverse poplar gall aphid, *Pemphigus populi-transversus* Riley, on the petioles and leaf bases of *Populus* sp.

the leaves of *Populus* spp. A single alate specimen was taken at Zapallar, Province of Aconcagua, November 27, 1950.

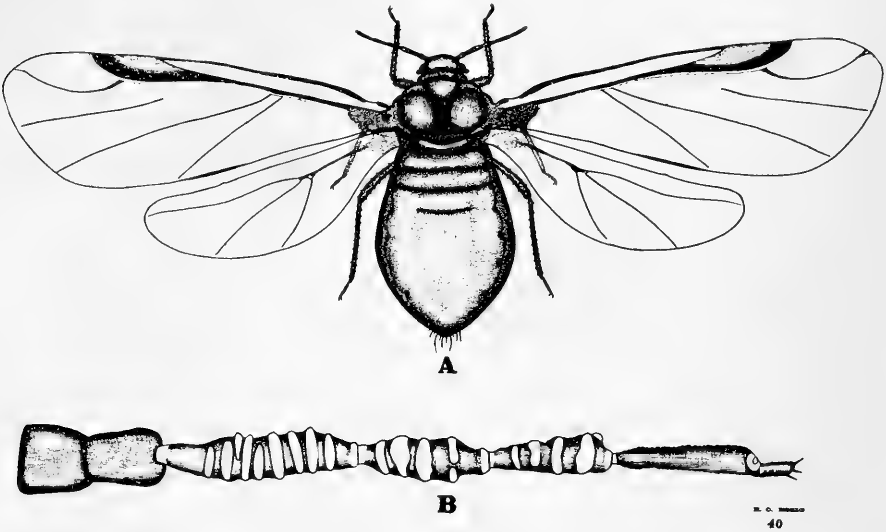


Figure 56. Bead-like cottonwood gall aphid, *Thecabius populi-monilis* (Riley). A, alate; B, antenna of alate enlarged.

INDICE DE LAS PLANTAS HUESPEDES

HOST-PLANT INDEX

- Abeto. Véase *Abies* sp.
- *Abies* sp.
  - **Cinara grossus** (Kalt.), Argentina.
  - **Cinara hyalina** (Koch). Argentina.
  - **Dreyfusia nordmanniana** Ecks. Argentina.
- Abrojo. Véase *Xanthium* sp.
- *Abutilon* sp.
  - **Myzus persicae** (Sulzer). Argentina.
- *Acacia* sp.
  - **Aphis fabae** Scopoli, Argentina.
    - **medicaginis** Koch. Argentina.
- *Acacia mansa*. Véase Sesbania punicea (D. C.).
- Achicoria. Véase *Chicorium intybus* L.
- *Acrostichum* sp. Helecho.
  - **Idopterus nephrelepidis** Davis. Argentina.
- Adelfa. Véase *Nerium* spp.
- *Adesmia* sp.
  - **Aphis laburni** Kalt.
- *Adiantum* sp. Helecho.
  - **Idiopterus nephrelepidis** Davis. Argentina.
- *Agave* sp. (Maguey, cabuya).
  - **Aphis rumicis** L. Peru.
- Agraciejo. Véase *Berberis* sp.
- Aguacate Véase *Persea americana* Mill.
- Ají. Véase *Capsicum* spp.
- Alamo. Véase *Populus* spp.
- Albaricoque. Véase *Prunus armeniaca* L.
- Alcaucil. Véase *Cynara scolymus* L.
- Alfalfa. Véase *Medicago sativa* L.
- Algodonero. Véase *Gossypium* spp.
- Alhelí. Véase *Mathiola incana*.
- Almendro. Véase *Prunus domestica* L. (*P. communis* Huds.)
- Altamisa. Véase *Descurainia appendiculata* (Gris.).
- *Alstrœmeria* sp.
  - **Aphis alstroemeria**, n. sp. Chile.
- *Amaryllis belladonna* L.
  - **Aphis gossypii** (Glover).
- *Andropogon bicornis* L.
  - **Hysteroneura ogloblini** Blanchard. Argentina.
- *Anethum graveolens* L.
  - **Cavariella aegopodii** (Scopoli). Argentina.
  - **Macrosiphum solanifolii** (Ashm.). Chile.
- Anís. Véase *Pimpinella anisum* L.
- *Antirrhinum majus* L.
  - **Macrosiphum solanifolii** (Ashm.). Argentina.
  - **Myzus persicae** (Sulzer). Argentina.
- Apio. Véase *Apium graveolens* L.
- *Apium graviolens* L.
  - **Cavariella aegopodii** (Scop.). Argentina.
  - **Trifidaphis phaseoli** (Pass.). Argentina.
- *Arachis hypogaea* L. (cacahue, cacahuate).
  - **Aphis laburni** Kalt. Argentina.
  - **Aphis medicaginis** Koch. Argentina.
- *Araujia sericofera* Bert.
  - **Aphis nerii** B. d. Fonsc. Argentina.
- Arrayán. Véase *Orthostemon sellowianus* Berg.
- Arroz. Véase *Oryza sativa* L .
- *Artemisia* spp.
  - **Macrosiphum ambrosiae** (Thomas). Argentina, Chile.
  - **Aphis medicaginis** Koch. Chile.
- *Arum* sp.
  - **Pentalonia nigronervosa** Coquer. Argentina, Brazil.
- *Asclepias* sp.
  - **Aphis gossypii** Glover. Argentina, Peru.
  - **Aphis nerii** B. d. Fonsc. Bolivia, Peru.
  - **Macrosiphum solanifolii** (Ashm.). Peru.
- *Asclepias curassavica* L.
  - **Aphis nerii** B. d. Fonsc. Argentina.
- *Asparagus officinalis* L.
  - **Myzus persicae** (Sulzer). Argentina.
- *Aster* spp.
  - **Brachycaudus helichrysi** (Kalt.). Argentina.
  - **Macrosiphum lizerianum** Blanchard. Argentina.

- Astralago. Véase *Astragalus*
- **Astragalus** sp. (astragalo).
  - **Aphis medicaginis** Koch. Argentina, Peru.
- *Atriplex* sp.
  - **Aphis gossypii** Glover. Colombia.
- Avellano. Véase *Corylus avellana* L.
- Avena. Véase *Avena sativa* L.
- *Avena sativa* L.
  - **Rhopalosiphum maidis** (Fitch). Argentina.
  - **Toxoptera graminum** (Rondani). Argentina.
- Azucena. Véase *Amaryllis belladonna* L. and Lilium spp.
- *Baccharis* spp.
  - **Brachycaudus helichrysi** (Kalt.). Argentina.
  - **Macrosiphum ambrosiae** (Thomas). Chile.
    - **chilensis**, n. sp. Chile.
    - **cordobensis** Blanchard. Argentina.
    - **huantana** n. sp. Chile.
    - **lizerianum** Blanchard. Argentina.
    - **macolai** Blanchard. Argentina.
    - **tucumani** n. sp. Argentina, Chile.
  - **Aphis gossypii** Glover. Colombia.
    - **medicaginis** Koch. Chile.
- *Baccharis melastomaefolia* Gris.
  - **Brachycaudus helichrysi** (Kalt.). (Bl.). Argentina.
  - **Aphis gossypii** Glover. Argentina.
  - **Macrosiphum littoralis** Blanchard. Argentina.
- *Baccharis salicifolia* Pers.
  - **Macrosiphum macolai** Blanchard. Argentina.
- Baladre. Véase *Nerium* spp.
- *Barnadesia odorata* Griseb.
  - **Myzus persicae** (Sulzer). Argentina.
- Batata. Véase *Ipomoea batatas* (L.).
- *Begonia* sp.
  - **Aphis gossypii** Glover. Argentina.
  - **Aulacorthum pseudorosaefolium** Blanchard. Argentina.
  - **Myzus ornatus** Laing. General distribution.
    - **persicae** (Sulzer). Argentina.
- *Bellis perrenis* L.
  - **Myzus persicae** (Sulzer). Argentina.
- *Berberis* sp. (Berbero, agracejo.)
  - **Aphis illinoisensis** Shimer. Chile.
- *Berberis buxifolia* Lam.
  - **Aphis patagonica** Blanchard. Argentina.
- Berbero. Véase *Berberis* sp.
- *Beta vulgaris* L.
  - **Myzus persicae** (Sulzer). Argentina.
- *Bidens megapotamica* Spreng.
  - **Aphis coreopsidis** (Thomas). Argentina.
- *Bignonia* sp.
  - **Aphis gossypii** Glover. Chile.
  - **Myzus ornatus** Laing. Chile.
- *Bœhmeria nivea* Gaud.
  - **Myzus persicae** (Sulzer).
- Bonetero. Véase *Euonymus* sp.
- *Brassica nigra* L. (Mostaza negro.)
  - **Brevicoryne brassicae** (L.). Argentina, Brazil, Chile, Peru.
  - **Rhopalosiphum pseudobrassicae** (Davis). Argentina.
- *Brassica oleracea* L. Coliflor.
  - **Brevicoryne brassicae** (L.). Argentina, Brazil, Chile, Peru, Trinidad Island.
  - **Myzus persicae** (Sulzer). Argentina.
- *Brassica* rapa L.
  - **Brevicoryne brassicae** (L.). Argentina, Chile, Brazil, Peru.
  - **Myzus persicae** (Sulzer). Argentina.
  - **Rhopalosiphum pseudobrassicae** (Davis). Argentina.
- *Brassica sinapistrum* Boisd.
  - **Brevicoryne brassicae** (L.). Argentina.
- *Bromus* sp.
  - **Rhopalosiphum prunifoliae** (Fitch). Argentina.
- *Bromus unioloides* Kth.
  - **Rhopalosiphum psundoavenae** (Patch). Argentina.
- Cabay. Véase *Agave.*
- Cacahuate. Véase *Arachis hypogaea* L.
- Cacahue. Véase *Arachis hypogaea* L.
- Cacao. Véase *Theobroma* sp.
- Cacto. Véase
  - *Cactus* spp.
  - *Epiphyllum* sp.
- Cafe. Véase *Coffea* sp.
- Calabaza. Véase *Cucurbita* spp.

Calendula officinalis L.
  Brachycaudus helichrysi (Kalt.). Peru.
  Macrosiphum solanifolii (Ashm.). Peru.
Camelia. Véase *Camellia* sp.
Camellia spp.
  Aphis camellicola Del G. Argentina.
  Macrosiphum rosae (Linn.).
  Toxoptera aurantii (B. d. Fonsc.). Cosmopolitan.
Caña de azúcar. Véase *Saccharum officinarum* L.
Cañamo. Véase *Cannabis sativa* L.
Canna sp.
  Rhopalosiphum nymphaeae Linn. Peru.
Cannabis sativa L. (canamo).
  Myzus persicae (Sulzer). Argentina.
Capsicum spp. (Ají).
  Myzus persicae (Sulzer). Argentina.
Capparis spinosa L.
  Brevicoryne brassicae (Linn.). Peru.
  Myzus persicae (Sulzer). Peru.
Cardencha. Véase *Dipsacus fullonum* L.
Cardoncillo. Véase *Eryngium paniculatum* Cav.
Cardo negro. Véase *Cirisium lanceolatum* (L.).
Cardos. Véase *Carduus* sp.
Carduus spp.
  Macrosiphum solanifolii (Ashmead). Argentina.
Carex spp.
  Rhopalosiphum maidis (Fitch).
Carum sp.
  Hydaphis conii (Davidson). Chile.
Carum carvi L. (Carvi).
  Cavariella aegopodii (Scopoli). Argentina.
Carvi. Véase *Carum carvi* L.
Cassia sp.
  Aphis medicaginis Koch. Chile, Peru.
Cassia aphylla Cav.
  Aphis gossypii Glover. Argentina.
    medicaginis Koch. Chile, Peru.
Cassia bacillaris. (Taro).
  Aphis gossypii (Glover). Trinidad Island.
Castanea sativa Mill. (castaño).
  Myzocallis castanicola Baker. Argentina.
Castaño. Véase *Castanea* spp.
Casuarina sp.
  Aphis gossypii Glover. Peru.
Cebada. Véase *Hordeum vulgare* L.
Cebadilla. Véase *Bromus unioloides* Kth.
Centeno. Véase *Secale cereale* L. (Rye).
Cereus sp. (Genero de cactos).
  Macrosiphum solanifolii (Ashmead). Chile.
  Myzus persicae (Sulzer). Chile.
    ornatus Laing. Chile.
  Aphis medicaginis Koch. Chile.
Cerraja. Véase *Sonchus oleraceus* L.
Cestrum parqui L'Herit. (Duraznillo negro).
  Aphis rumicis L. Argentina.
Chaenomeles japonica (Thunb). Lindl. (Membrillo japones.)
  Aphis rumicis L. Argentina.
Chaguar de las penas. Véase *Dyckia floribunda* Gris.
Chayote. Véase *Sechium edule* Sw.
Chenopodium sp.
  Aphis gossypii Glover. Argentina.
  Myzus persicae (Sulzer). Argentina.
Chilca. Véase *Erigeron* spp., *Baccharis* spp.
Chrysanthemum sp. (Crisantemo).
  Aphis rumicis L. Chile.
    medicaginis Koch. Argentina.
  Brachycaudus helichrysi (Kalt.). Peru.
  Capitophoraphis williamsoni Blanchard, Argentina.
  Macrosiphum artemisiae (Thomas). Peru.
Chrysanthemum frutescens L.
  Macrosiphum solanifolii (Ashmead). Peru.
Chrysanthemum indicum L. (Crisantemo).
  Aphis fabae Scopoli. Argentina.
  Brachycaudus helichrysi (Kalt.). Argentina.
  Macrosiphoniella sanborni (Gillette), Argentina.
Chrysanthemum maximum Ramond.
  Brachycaudus helichrysi (Kalt.). Peru.

Cicer arietinum L.
- **Rhopalosiphum pseudoavenae** (Patch). Argentina.

Cichorium endivia L. (Escarola).
- **Amphorophora sonchi** (Oestlund). (**A. cosmopolitanus** Mason.) Argentina.
- **Macrosiphum sonchi** (L.). Argentina.

Cichorium intybus L. (Achicoria).
- **Macrosiphum sonchi** L. Argentina.

Ciclamen. Véase *Cyclamen indicum* L.

Cicuta sp.
- **Aphis medicaginis** Koch. Argentina.

Cicuta. Véase *Conium maculatum* L.

Cineraria sp.
- **Brachycaudus helichrysi** (Kalt.). Argentina.
- **Myzus persicae** (Sulzer). Argentina.

Ciprés. Véase *Cupressus* sp.

Cirsium lanceolatum (L.). (cardo negro).
- **Aphis fabae** Scopoli. Argentina.
  - **rumicis** L. Chile.
  - **medicaginis** Koch. Argentina.

Ciruelo. Véase *Prunus domestica* L.

Citrullus vulgaris Schrad.
- **Aphis gossypii** Glover. Argentina.

Citrus spp.
- **Aphis citricidus** (Kirkaldy). Argentina, Chile, Peru.
  - **gossypii** Glover. Argentina.
  - **laburni** Kalt. Argentina.
- **Macrosiphum solanifolii** (Ashmead). Argentina.
- **Myzus circumflexus** (Buckton). Argentina.
- **Paratoxoptera argentinensis** (Blanchard). Argentina.
- **Toxoptera aurantii** (B. d. Fonsc.). Argentina, Brazil, Trinidad Island.

Clavel. Véase *Dianthus caryophyllus* L.

Clematide. Véase *Clematis* sp.

Clematis sp. (clematide).
- **Aphis nerii** (B. d. Fonsc.). Argentina.

Coccoloba sp.
- **Toxoptera aurantii** (B. d. Fonsc.). Tropics.

Coffea (cafe).
- **Toxoptera aurantii** (B. d. Fonsc.). Tropics.

Coliflor. Véase *Brassica oleracea* L.

Colocasia esculenta (L.). (Taro.)
- **Aphis gossypii** Glover. Trinidad Island.

Comida de víbora. Véase *Lycium argentinum* Hier.

Comino. Véase *Cuminum cyminum* L. Argentina.

Compositae (various genera and species)
- **Aphis coreopsidis** Thomas. Colombia.
  - **gossypii** Glover. Colombia.
  - **medicaginis** Koch. Argentina.
  - **rumicis** Linn. Peru.
- **Macrosiphum beretica** Blanchard. Argentina.
  - **bonariensis** Blanchard. Chile.
  - **griersoni** Blanchard. Chile.
  - **lizerianum** Blanchard. Argentina.
  - **muermosa**, n. sp. Chile.
  - **nuble**, n. sp. Chile.

Conejitos. Véase *Antirrhinum majus* L.

Conium maculatum L.
- **Aphis fabae** Scopoli. Argentina.

Convolvulus sp. (Domperdo, Dondiego de dia).
- **Macrosiphum solanifolii** (Ashmead). Chile.
- **Myzus persicae** (Sulzer). Chile.

Coqueta. Véase *Bellis perennis* L.

Corona de novia. Véase *Spiraea chamaedrifolia* L.

Corylus avellana L. (Avellano).
- **Myzocallis coryli** (Gœze).

Cosmos sp.
- **Aphis medicaginis** Koch. Argentina.
- **Macrosiphum solanifolii** (Ashmead). Argentina.
- **Myzus persicae** (Sulzer). Argentina.

Cosmos bipennatus Cav.
- **Aphis fabae** Scopoli. Argentina.
- **Macrosiphum lizerianum** Blanchard. Argentina.
  - **solanifolii** (Ashmead). Argentina.
- **Myzus persicae** (Sulzer). Argentina.

Crataegus sp. (Espino).
- **Aphis gossypii** Glover, Argentina.

Crisantemo. Véase *Chrysanthemum indicum* L.

Cristaria corchorifolia Gris.
 Macrosiphum solanifolii (Ashmead). Argentina.

Cucumis melo L.
 Aphis gossypii Glover. Argentina.

Cucumis sativus L. (Cohombro o pepino).
 Aphis gossypii Glover. Trinidad Island.

Cucurbita maxima L. (Calabaza).
 Aphis gossypii Glover. Brazil, Chile, Peru, Trinidad Island.
 Macrosiphum solanifolii (Ashmead). Argentina, Chile.

Cuminum cyminum L. (Comino).
 Myzus persicae (Sulzer). Argentina.

Cupressus macrocarpa Hartw. (Cipres).
 Cinara fresai Blanchard. Argentina.

Cyclamen indicum L. (Ciclamen).
 Myzus circumflexus (Buckton). Argentina.

Cycloma spp.
 Aphis gossypii Glover. Argentina.

Cydonia japonica Pers. (Membrillo japones.)
 Aphis fabae Scopoli. Argentina.
  gossypii Glover. Argentina.

Cydonia vulgaris Pers. (Membrillo.)
 Aphis gossypii Glover. Argentina.

Cynara scolymus L. (Alcaucil).
 Capitophorus braggi (Gillette). Argentina, Chile.
 Macrosiphum griersoni Blanchard. Argentina.
  solanifolii (Ashmead). Chile.
 Myzus persicae (Sulzer). Argentina.

Cynodon dactylon (L.).
 Paraprociphilus graminis Blanchard. Argentina.

Dahlia sp.
 Aphis medicaginis Koch. Argentina.

Dahlia variabilis Desf. (Dalia).
 Aphis fabae Scopoli. Argentina.

Dalia. Véase *Dahlia variabilis* Desf.

Damasco. Véase *Prunus armeniaca* L.

Datura sp.
 Macrosiphum solanifolii (Ashmead). Peru.
 Myzus persicae (Sulzer). Chile, Peru.

Daucus carota L. (Zanahoria).
 Cavariella aegopodii (Scopoli). Argentina.

Descurainia appendiculata (Gris.).
 Myzus persicae (Sulzer). Argentina.

Dianthus caryophyllus L. (Clavel).
 Myzus persicae (Sulzer). Argentina.
 Trifidaphis phaseoli (Passerini). Argentina.

Diente de leon. Véase *Taraxacum vulgare* (Lam.).

Dipsacus fullonum L. (Cardencha).
 Macrosiphum rosae (Linn.). Cosmopolitan.

Dipsacus sylvestris Huds.
 Macrosiphum rosae (Linn.) Cosmopolitan.

Domperdo. Véase *Convolvulus* spp.

Dondiego de dia. Véase *Convolvulus* spp.

Duraznillo negro. Véase *Cestrum parqui* L'Herit.

Duraznero. Véase *Prunus persica* L.

Dyckia floribunda Gris. (Chaguar).
 Aphis fabae Scopoli. Argentina.
  gossypii Glover. Argentina.
  medicaginis Koch. Argentina.

Echinodorus sp.
 Rhopalosiphum nymphaeae (L.). Brazil.

Encelia sp.
 Macrosiphum ambrosiae (Thomas). Peru.

Epiphyllum sp.
 Aphis rumicis L. Chile.

Eragrostis pilosa (L.).
 Carolinaia ogloblini (Blanchard). **(Hysteroneura)**. Argentina.

Erigeron sp.
 Macrosiphum cordobensis Blanchard. Argentina.
  macolai Blanchard. Argentina.

Eriobotrya japonica Lindl.
 Macrosiphum rosae (L.). Argentina.

- *Eryngium* sp.
  - **Aphis eryngii** Blanchard. Argentina.
    - **medicaginis** Koch. Argentina.
- *Eryngium paniculatum* Cav.
  - **Aphis fabae** Scopoli. Argentina.
- Escarola. Véase *Cichorium endivia* L.
- Espadana. Véase *Typha* sp.
- Esparrago. Véase *Asparagus officinalis* L.
- Espinaca. Véase *Spinacia oleracea* L.
- Espino. Véase *Crataegus* sp.
- Eucalipto. Véase *Eucalyptus globulus* Lab.
- *Eucalyptus globulus Lab.* (Eucalipto).
  - **Aphis fabae** Scopoli. Argentina.
    - **medicaginis** Koch. Argentina.
- *Eugenia* sp. (Arrayau).
  - **Aphis rumicis** L. Argentina.
    - **gossypii** var. **malvoides** Van der Goot. Argentina.
- *Euonymus* sp.
  - **Aphis bazzii** Blanchard. Argentina.
- *Euonymus europaea* L.
  - **Aphis fabae** Scopoli. Argentina.
- *Euonymus japanica* Thunb.
  - **Aphis fabae** Scopoli. Argentina.
    - **medicaginis** Koch. Argentina.
- *Eyphorbia portulacoides* Speng.
  - **Aphis pseudopulchella** Blanchard. Argentina.
- *Feijoa* sp. (Feijao).
  - **Smynthurodes betae** Westwood. [**Trifidaphis phaseoli** (Pass.)]. Brazil.
- *Ficus* sp. (Higuero).
  - **Toxoptera aurantii** (B. d. Fonsc.). Cosmopolitan.
- Flox. Véase *Phlox*.
- *Foeniculum vulgare* Gaertn. (Hinojo).
  - **Aphis fabae** Scopoli (?). Argentina.
    - **medicaginis** Koch. Argentina.
  - **Cavariella aegopodii** (Scopoli). Argentina.
  - **Sappaphis apiifolia** (Theobald). Argentina.
- *Fragaria vesca* L. Frutilla.
  - **Capitophorus fragaefolii** (Ckll.). Argentina.
- Frijol. Véase *Phaseolus*.
- Frutilla. Véase *Fragaria vesca* L.
- *Fuchsia* spp.
  - **Myzus ornatus** Laing. Peru, Chile (?).
- Fucsia. Véase *Fuchsia*.
- Garbanzo. Véase *Cicer arietnum* L.
- *Gardenia florida* L. (Jazmin).
  - **Aphis gossypii** Glover. Argentina.
  - **Toxoptera aurantii** (B. d. Fonsc.). Cosmopolitan.
- Genero de cactos. Véase *Cereus* sp.
- Geranio. Véase *Pelargonium* spp.
- *Gerbera jamesoni* Balus.
  - **Aphis fabae** Scopoli. Argentina.
    - **medicaginis** Koch. Argentina.
  - **Macrosiphum ambrosiae** (Thomas). Peru.
- Gladiolo. Véase *Gladiolus communis* L.
- *Gladiolus communis* L. (Gladiolo).
  - **Aphis fabae** Scopoli. (?). Argentina.
    - **medicaginis** Koch. Argentina.
- *Gliricidia sepium (G. maculata).*
  - **Aphis medicaginis** Koch. Trinidad Island.
- *Gloxinia* sp.
  - **Aphis medicaginis** Koch. Argentina.
- *Gossypium* spp. (Algodonero).
  - **Aphis gossypii** Glover. Argentina, Peru, Trinidad Island.
  - **Macrosiphum solanifolii** (Ashmead). Peru.
- *Gourliea decorticans* Gill. & Hook.
  - **Aphis laburni** Kalt. Argentina.
- *Gramineæ* (Hierba).
  - **Geoica lucifuga** (Zehntner). Argentina.
  - **Rhopalosiphum maidis** (Fitch). Brazil.
    - **splendens** (Theobald). (sobre Raices). Peru.
  - **Toxoptera graminum** (Rondani). Brazil.
- Granada. Véase *Punica granatum* L.
- Grosellero. Véase *Ribes* sp.
- Guava. Véase *Psidium guajava* L.
- Guayabo. Véase *Psidium guajava* L.
- Guayava. Véase *Orthostemon sellowianus* Berg.
- Guayule. Véase *Parthenium acetatum* Gray.
- Guindo dulce. Véase *Prunus avium* L.

Guisante. Véase *Lathyrus* sp.

Haba. Véase *Vicia faba* L.

Haya sudamericana. Véase *Nothofagus* sp.

Hedera helix L. (Hiedra).
Aphis hederae Kaltenbach. Argentina.

Helecho. Véase *Acrostichum, Adiantum, Nephrolepis.*

Hibisco. Véase *Hibiscus* sp.

Hibiscus sp. (Hibisco).
Aphis gossypii Glover. Argentina, Trinidad Island.
Toxoptera aurantii (B. d. Fonsc.). Cosmopolitan.

Hiedra. Véase *Hedera helix* L.

Higuera. Véase *Ficus* sp.

Hinojo. Véase *Foeniculum vulgare* Gaertn.

Holcus halepense (L.). Véase *Sorghum halepense.*

Hordeum vulgare L. (Cebada).
Aploneura lentici Pass. Argentina.
Rhopalosiphum maidis (Fitch). Argentina.
Sipha carrerai Blanchard. Argentina.
Toxoptera graminum (Rondani). Argentina.

Hyptis spicata Poit.
Macrosiphum hyptidis Blanchard. Argentina.

Ilex paraguayensis Bonop. (Yerba mate).
Toxoptera aurantii (B. d. Fonscolombe). Argentina.

Imopœa batatas Lam. (Batata).
Macrosiphum solanifolii (Ashmead). Argentina.

Iris florentina L.
Yezabura tulipae (B. d. Fonsc.). Argentina.

Jacaranda sp.
Aphis gossypii Glover. Chile.

Jacaranda ovalifolia R. Br.
Aphis gossypii Glover. Argentina.

Jazmín. Véase *Gardenia florida* L.

Jazmín de Chile. Véase *Mandevillea suaveolens* Lindl.

Judía. Véase *Phaseolus* spp.

Juglans regia L. (Nogal).
Tuberolachnus salignus (Gmelin). Argentina.

Juniperus uvifera Don. Véase *Philgerodendron uviferum* (Don) Florin.

Lactuca spp. (Lechuga).
Amphorophora sonchi (Oestlund) (**A. cosmopolitanus** Mason.) Argentina, Brazil.
Macrosiphum lizerianum Blanchard. Argentina.
Myzus persicae (Sulzer). Argentina.

Lagenaria siceraria (Mol.) Standl.
Aphis gossypii Glover. Trinidad Island.

Lantana sp.
Macrosiphum solanifolii (Ashmead). Colombia.

Lathyrus sp. (Guisante, Pesal.)
Macrosiphum solanifolii (Ashmead). Cosmopolitan.

Lathyrus sativus L. (Guisante. Pesal.)
Acyrthosiphon onobrachis (B. d. Fonsc.) [**Macrosiphum pisi** (Kalt.).] Cosmopolitan.
Macrosiphum solanifolii (Ashmead). Chile.

Laurel negro. Véase *Nectandra* sp.

Laurel rosa. Véase *Nerium oleander* L.

Laurel fino. Véase *Viburnum tinus* L.

Lavatera arborea L. (Malvon).
Aphis gossypii Glover. Argentina.

Lechuga. Véase *Lactuca sativa* L.

Leguminosae.
Acyrthosiphon onobrachis (B. d. Fonsc.). Peru.
Aphis medicaginis (Koch). Chile, Colombia, Peru.
rumicis Linn. Argentina.

Lens esculenta Moench (Lenteja).
Aphis laburni Kalt. Argentina.

Lenteja. Véase *Lens esculenta* Moench.

Lepidium sp.
Aphis gossypii Glover, Argentina.
Rhopalosiphum pseudobrassicae (Davis). Argentina.

Libocedrus cupressoides Sargent. Véase *Pilgerodendron uvifera* (Don) Florin.

Libocedrus tetragona (Hooker).
Véase *Pilgerodendron uvifera* (Don) Florin.

Liliaceae.
Myzus circumflexus (Buckton). Argentina.

Lilium sp. (Azucena).
Aphis gossypii Glover. Argentina.

Lonicera confusa DC (Madreselva).
Hyadaphis conii (Davidson). Argentina.
Myzus persicae (Sulzer). Argentina.

Loto. Véase *Nelumbium* sp.

Lycium argentinum Hier. (Comida de víbora).
Aphis rumicis L. Argentina.

Lycopersicon esculentum L. (Tomate, Tomatera).
Aphis gossypii Glover. Argentina.
rumicis L. Argentina, Brazil.
Macrosiphum solanifolii (Ashmead). Argentina, Chile.
Myzus persicae (Sulzer). Argentina.

Madreselva. Véase *Lonicera confusa* DC.

Maguey. Véase *Agave.*

Maíz. Véase *Zea mays* L.

Malva spp.
Macrosiphum solanifolii (Ashmead). Argentina, Peru.
solutum Blanchard. Argentina.
urtica (Schr.). Argentina.
Myzus persicae (Sulzer). Argentina.

Malva rosa. Véase *Pelargonium graveolens* L'Herit.

Malvón. Véase *Lavatera arborea* L.

Manderillea suaveolens Lindl. (Jazmin de Chile).
Aphis gossypii Glover. Argentina.
Toxoptera aurantii (B. d. Fonsc.). Argentina.

Mangifera sp. (Mango).
Toxoptera aurantii (B. d. Fonsc.). Tropical.

Maní. Véase *Arachis hypogaea* L.

Manzano. Véase *Pyrus malus* L.

Mango. Véase *Mangifera* sp.

Matambra.
Aphis senecionicoides Blanchard. Argentina.

Mathiola hederacea (Rabanito).
Rhopalosiphon pseudobrassicae (Davis). Argentina, Peru.
Myzus persicae (Sulzer). Argentina.

Mathiola incana L.
Myzus persicae (Sulzer). Argentina.

Medicago sativa L. (Alfalfa).
Aphis laburni Kalt. Argentina.
gossypii Glover. Argentina.

Melón. Véase *Cucumis melo* L.

Membrillo. Véase *Cydonia vulgaris* Pers.

Membrillo japones. Véase *Cydonia japonica* Pers.

Menta. Véase *Mentha arvensis* L.

Mentha arvensis L.
Kaltenbachiella pallida (Haliday). (**K. menthae** Schout.). Argentina.

Mimosa sp.
Hysteroneura ogloblini Blanchard. Argentina.

Molle. Véase *Schinus dependens* (Ortega).

Morrenia odorata (H. & Arn.).
Aphis gossypii Glover. Argentina.

Mostaza negra. Véasa *Brassica nigra.* (L.).

Mostaza silvestre. Véase *Brassica sinapistrum* Boise.

Musa sp. (Banana).
Pentalonia nigronervosa Coquer. Brazil, Trinidad Island.

Montezuma speciosissima
Aphis gossypii *Glover.* Trinidad Island.

Nabo. Véase *Brassica rapa* L.

Nasturcia. Véase. *Nasturtium officinalis* L.

Nasturtium officinale R. Br. (nasturcia).
Aphis medicaginis Koch. Chile.
Rhopalosiphum pseudobrassicae (Davis). Bolivia.

Nectandra sp. (Laurel negro).
Neolizerius tuberculatus Blanchard. Argentina.

Nelumbium sp. (loto, ninfea).
Rhopalosiphum nymphaeae (Linn.). Brazil.

- *Nephrolepis* spp. (Helecho).
  - **Idiopterus nephrelepidis** (Davis). Argentina.
- *Nerium oleander* L. (adelfa, baladre).
  - **Aphis nerii** (B. d. Fonsc.). Argentina, Chile.
- *Nicotiana* sp. (tabaco).
  - **Macrosiphum ambrosiae** (Thomas). Peru.
    - **solanifolii** (Ashmead). Peru.
  - **Myzus persicae** (Sulzer). Peru.
- Ninfea. Véase *Nelumbium* sp.
- Nispero. Véase *Eriobotrya japonica* (Thunb.).
- Nogal. Véase *Juglans regia* L.
- Noguera. Véase *Juglans regia* L.
- *Nothophagus* sp.
  - **Neuquenaphis edwardsi** (Laing). Argentina.
- *Nothofagus dombei* Blume.
  - **Neuquenaphis michelbacheri** n. sp. Chile.
    - **chilensis**, n. sp. Chile.
  - **Spicaphis michelbacheri**, n. sp. Chile.
- *Nymphæa* sp.
  - **Rhopalosiphum nymphaeae** L. Brazil.
- *Ocotea acutifolia* (Nees.).
  - **Lizerius ocoteae** Blanchard. Argentina.
- Oleaceae.
  - **Aphis gossypii** Glover. Argentina.
- Olmo. Véase *Ulmus* spp.
- Ombu. Véase *Phytolacca dioica* L.
- *Onobrychis sativa* Lam.
  - **Aphis laburni** Kalt. Argentina.
- *Orchidaceae* (Orquidea).
  - **Myzus circumflexus** (Buckton). Argentina.
- Orquidea. Véase *Orchidaceae.*
- *Orthostemon sellowianus* Berg. (Guayava).
  - **Aphis gossypii** Glover. Argentina.
- Ortiga. Véase *Urtica* spp.
- *Oryza sativa* L.
  - **Aresha setigera** Blanchard. Argentina.
- Palmera. Véase *Phoenix* sp.
- Papa. Véase *Solanum tuberosum* L.
- *Parthenium acetatum* (Gray).
  - **Macrosiphum lizerianum** Blanchard Argentina.
- *Parthenium hysterophorus* L.
  - **Aphis gossypii** Glover. Argentina.
  - **Macrosiphum lizerianum** Blanchard. Argentina.
- Pastinaca. Véase *Pastinaca sativa* L.
- *Pastinaca sativa* L. (Pastanica).
  - **Cavariella aegopodii** (Scopoli). Argentina.
- Patata. Véase *Solanum tuberosum* L.
- *Pelargonium* sp. (Geranio).
  - **Aulacorthum pelargonii** (Kalt.). Peru.
  - **Macrosiphum solutum** (Blanchard).
- *Pelargonium graveolens* L'Herit. (Malva rosea).
  - **Macrosiphum bosqui** Blanchard. Argentina.
- Pelón. Véase *Prunus persica* var. *nucipersica* Schn.
- Peral. Véase *Pyrus communis* L.
- *Persea americana* Mill.
  - **Aphis gossypii** Glover. Argentina.
- *Persea* sp.
  - **Toxoptera aurantii** (B. d. Fonsc.). Colombia.
- Pesal. Véase *Lathyrus sativus* L.
- *Phaseolus* sp. (Judia, Frijol).
  - **Macrosiphum solanifolii** (Ashmead). Chile.
  - **Smynthurodes betae** (Westwood). [**Trifidaphis phaseoli** (Passerini)]. Argentina.
- *Phaseolus lunatus* L.
  - **Aphis laburni** Kalt. Arengtina.
    - **medicaginis** Koch. Argentina.
- *Phaseolus vulgaris* L. (Judia, Frijol).
  - **Aphis gossypii** Glover. Brazil.
  - **Macrosiphum solanifolii** (Ashmead). Peru.
- *Phlox* sp. (Flox).
  - **Myzus persicae** (Sulzer). Peru.
- *Phœbe porphyria* Griseb.
  - **Lizerius ocoteae** Blanchard. Argentina.
- *Phoenix* sp.
  - **Aphis fabae** Scopoli. Argentina.
    - **medicaginis** Koch. Argentina.
- *Phragmites phragmites* (L.). (*P. communis* Trin.).
  - **Hyalopterus arundinis** (Fab.). Chile.

Phytolacca dioica L.
Toxoptera aurantii (B. d. Fonsc.). Argentina.
Picris sp.
Macrosiphum ambrosiae (Thomas). Peru.
Pilgerodendron uviferum (Don) Florin.
Chileaphis michelbacheri n. sp. Chile.
Pimpinella anisum L.
Cavariella aegopodii (Scopoli). Argentina.
Myzus persicae (Sulzer). Argentina.
Pino. Véase *Pinus* spp.
Pinus spp.
Pineus havrylenkoi Blanchard. Argentina.
Pinus halepensis Mill.
Cinara pini L. (**Lachnus pineti** Koch). Argentina.
Pinus radiata Don.
Cinara pini L. (**Lachnus pineti** Koch). Argentina.
Pinus pinaster Ait.
Cinara pini L. (**Lachnus pineti** Koch). Argentina.
Piretro. Véase *Pyrethrum* sp.
Pittosporum sp.
Aphis fabae Scop. var. **bazzii** Blanchard. Argentina.
Polipodia. Véase Helecho, Ploypodiaceae.
Polypodiaceae (Polypodia).
Idiopterus nephrelepidis (Davis). Cosmopolitan.
Populus alba var. *pyramidalis* Bunge (Alamo).
Pemphigus bursarius (L.). Argentina.
Phloemyzus passerinii (Signoret). Argentina.
Populus angulata Ait. (Alamo).
Pemphigus populi-transversus Riley. Argentina, Brazil.
Populus canadensis Moench (Alamo).
Pemphigus populi-transversus Riley. Argentina.
Populus simonii Carr (Alamo).
Pterocomma populeum (Kalt.). (**Aphis populea** Kalt.) Argentina.

Porotilla de los sapos. Véase *Vigna luteola* (Jacq.).

Prunus spp.
Aphis prunicola Kalt. Brazil.
Appelia schwartzi (Börner). Argentina.
Brachycaudas helichrysi (Kalt.). Argentina, Chile.
persicae-niger (Smith). Argentina.
Hyalopterus arundinis (Fab.). Chile.
Myzus persicae (Sulzer). Argentina.
Rhopalosiphum nymphææ (L.). Cosmopolitan.

Prunus armeniaca L. (Damasco).
Brachycaudus schwartzi Böerner. Argentina.

Prunus avium L.
Brachycaudus helichrysi (Kalt.). Argentina.
Macrosiphum solanifolii (Ashmead). Argentina.

Prunus domestica L. (Ciruelo).
Brachycaudus schwartzi (Börner). Argentina.
helichrysi (Kalt.). Argentina, Brazil.
persicae-niger (Smith). Argentina.

Prunus persica L. (Duraznero).
Appelia schwartzi (Börner). Argentina.
Brachycaudus helichrysi (Kalt.). Argentina, Brazil, Chile.
persicae-niger (Smith). Argentina.
Myzus persicae (Sulzer). Argentina.

Psidium guajara L. (Guayabo, guayaba).
Aphis gossypii Glover.

Punica granatum L. (Granado).
Aphis gossypii Glover. Peru.
Macrosiphum solanifolii (Ashmead). Peru.

Pyrethrum sp. (Piretro).
Macrosiphum bonariensis Blanchard. Argentina.

Pyrus sp.
Myzus persicae (Sulzer). Argentina.

Pyrus communis L. (Peral).
  Aphis gossypii Glover. Argentina.
    laburni (Kalt.). Argentina.
  Eriosoma lanigerum (Hausmann). Brazil (?).
  Macrosiphum solanifolii (Ashmead). Argentina.

Pyrus malus L. (Manzano).
  Aphis gossypii Glover. Argentina.
    pseudopomi Blanchard. Argentina.
  Eriosoma lanigerum (Hausmann). Argentina, Brazil, Chile, Peru.
  Hyalopterus arundinis (Fab.). Chile.
  Macrosiphum solanifolii (Ashmead). Argentina.

Quercus sp.
  Tuberculoides querciplatensis Blanchard. Argentina.

Quercus ilex L.
  Tuberculoides grodsinskyi Blanchard. Argentina.

Quercus robur L.
  Tuberculoides elegans Blanchard. Argentina.

Rabanito. Véase *Raphanus sativus* L.

Ramino. Véase *Boehmeria nivea* Gaud.

Raphanus sativus L.
  Brevicoryne brassicae (L.). Argentina.
  Rhopalosiphum pseudobrassicae (Davis). Argentina.

Remolacha. Véase *Beta vulgaris* L.

Repollo. Véase *Brassica oleracea* L.

Revienta caballo. Véase *Solanum capsicastrum* Link., *S. sisymbrifolium* Lam.

Ribes sp.
  Aphis rumicis L. Chile.

Roble. Véase *Quercus* spp.

Robinia pseudoacacia L.
  Aphis laburni Kalt. Argentina.

Rosa. Véase *Rosa centifolia* y *R. gallica* L.

Rosa spp.
  Aulacorthum pseudorosaefolium Blanchard. Argentina.
  Macrosiphum rosae (Linn.). Argentina, Brazil, Chile, Peru.

Rosa centifolia and *R. gallica* L.
  Aulacorthum pseudorosaefolium Blanchard. Argentina.
  Macrosiphum rosae (L.). Argentina.
  Myzus rosarum (Kalt.). Argentina, Brazil.
  Passerinia tetrahoda (Walker). Argentina.

Rumex spp.
  Aphis rumicis Linn. Argentina, Chile.
  Myzus persicae (Sulzer). Argentina.

Rumex paraguayensis D. Parodi.
  Baizongiella solanophila Blanchard. Argentina.

Saccharum officinarum L. (caña de azucar).
  Rhopalosiphum maidis (Fitch). Argentina.
  Sipha flava Forbes. Argentina, Brazil, British Guiana.

Salix spp. (Sauce).
  Aphis neosaliceti Blanchard. Argentina.
  Cavariella aegopodii (Scopoli). Argentina.
  Tuberolachnus saligna (Gmelin). Argentina, Brazil, Chile, Peru.

Salix babylonica L.
  Aphis citricidus (Kirkaldy). Argentina.
  Cavariella aegopodii (Scopoli). Argentina.
  Paratoxoptera argentinensis Blanchard. Argentina.

Salix viminalis L. (Sauce "Osier").
  Tuberolachnus saligna (Gmelin). General.

Salsifí. Véase *Tragopogon porrifolius* L.

Sambucus australis Cham. & Schl.
  Aphis sambuci L. Argentina.

Sandía. Véase *Citrullus vulgaris* Schrad.

Sauce. Véase *Salix* spp.

Saùco. Véase *Sambucus australis* Chem. et Schl.

Schinus dependens Ortega.
  Aphis schinifoliae Blanchard. Argentina.

Scirpus sp.
  Rhopalosiphum maidis (Fitch). Argentina.
Scutia buxifolia Reiss.
  Toxoptera aurantii (B. d. Fonsc.). Argentina.
Secale cereale L. (Centeno).
  Rhopalosiphum prunifoliae (Fitch) (**R. pseudoavenae** Patch). Argentina.
Sechium edule Sw.
  Aphis gossypii Glover. Argentina.
Senecio spp.
  Brachycaudus helichrysi (Kalt.). Argentina.
  Macrosiphum capitophoroides Blanchard. Argentina.
  Myzus persicae (Sulzer). Argentina.
Senicio bonariensis Hook & Arn.
  Aphis fabae Scopoli. Argentina.
    medicaginis Koch. Argentina.
Sen-Sen. Véase *Cassia aphilla.*
Sesbania punicea (DC).
  Aphis laburni Kalt. Argentina.
    medicaginis Koch. Argentina.
Sida acuta Burm.
  Aphis gossypii Glover. Trinidad Island.
Sisymbrium Arnottianum Gill. & Hook.
  Rhopalosiphum sisymbrii Del Guercio. Argentina.
Solano. Véase *Solanum* spp.
  Aphis gossypii Glover.
Solanum spp.
  Aulacorthum pelargonii (Kalt.). Peru. (Casual ?).
  Aphis medicaginis Koch. Argentina.
    rumicis L. Argentina.
  Macrosiphum solanifolii (Ashmead). Peru.
  Myzus persicae (Sulzer). Argentina, Peru.
  Rhopalosiphum splendens (Theobald). Peru.
  Smynthurodes betae (Westwood). (**Trifidaphis phaseoli** (Passerini).)
Solanum capsicastrum Link.
  Aphis rumicis L. Argentina.
Solanum lycopersicum L. (Tomate, tomatera). See **Lycopersicon esculentum** L.
Solanum melongena (Berengena).
  Aphis gossypii Glover. Brazil, Trinidad Island.
Solanum nodiflorum Jacq.
  Aphis rumicis Linn. Argentina.
    solanophilus Blanchard. Argentina.
Solanum sisymbriifolium Lamb.
  Aphis gossypii Glover. Argentina.
    rumicis Linn. Argentina.
Solanum tuberosum L. (Patata, papa).
  Aphis gossypii Glover. Peru.
    rumicis Linn. Argentina.
  Aulacorthum pseudosolani (Theobald). Chile.
  Macrosiphum cordobensis Blanchard. Argentina, Peru.
    solanifolii (Ashmead). Argentina, Chile, Peru.
  Myzus persicae (Sulzer). Argentina, Bolivia, Peru.
  Smynthurodes betae (Westwood). [**Trifidaphis phaseoli** (Passerini)] Argentina.
Solidago sp.
  Brachycaudus helichrysi (Kalt.). Argentina.
Sonchus spp.
  Amphorophora lactucae (Kalt). Argentina.
    sonchi (Oestlund). Argentina, Brazil, Chile.
  Macrosiphum lizerianum Blanchard. Argentina.
    rosae (Linn.). Chile, Peru.
    solanifolii (Ashmead). Chile.
Sonchus oleraceus Linn.
  Amphorophora sonchi (Oestlund). Argentina.
Sorgo. Véase *Sorghum halepense* (L.).
Sorghum halepense (L.) (Sorgo).
  Rhopalosiphum maidis (Fitch). Brazii, Chile, Peru.
  Sipha flava Forbes. Argentina. Brazil.
Spinacio oleracea L.
  Brevicoryne brassicae (L.) Argentina.
  Macrosiphum solanifolii (Ashmead). Argentina.

- *Spiraea chamaedrifolia* L. (Cornoa de novia).
  - **Aphis fabae** Scopoli. Argentina.
  - **medicaginis** Koch. Argentina.
  - **pseudopomi** Blanchard. Argentina.
- *Straussia* sp.
  - **Toxoptera aurantii** (B. d. Fonsc.). Argentina.
- Sunchillo. Véase *Wedelia glauca* (Ort.).
- Sugarcane. See *Saccharum officinarum* L.
- Sorghum. See *Holcus halepensis* (L.).
- Suncho. Véase *Baccharis salicifolia* Pers.
- Tanaceto. Véase *Tanacetum vulgare* L.
- Tabaco. Véase *Nicotiana* sp.
- *Tanacetum vulgare* L.
  - **Macrosiphum bonariensis** Blanchard. Argentina.
  - **cocoensis** Blanchard. Argentina.
- *Taraxacum vulgare* (Lam.). (diente de leon).
  - **Macrosiphum macaloi** Blanchard. Argentina.
- Taro. Véase *Colocasia esculentum* L.
- Tasi. Véase *Araujia sericifera* Bert.
- Tasi fragante. Véase *Morrenia odorata* (Hook. & Arn.).
- *Theobroma* sp. (Cacao).
  - **Toxoptera aurantii** (B. d. Fonsc.) Trinidad Island.
- *Thuja occidentalis* L.
  - **Cupresobium juniperi** (DeGeer) **(Cinara)**. Argentina.
- *Thuja tetragona* Hooker. Véase *Philgerodendron uviferum* (Don) Florin.
- Tomate. Véase *Solanum lycopersicum* L.
- Tomatera. Véase *Solanum lycopersicum* L.
- *Tragopogon porrifolius* L.
  - **Anuraphis tragopogonis** (Kalt.). Argentina.
- Trigo. Véase *Triticum vulgare* Vill.
- *Triticum vulgare* Vill.
  - **Pemphigus populi-transversus** Riley. Argentina.
  - **Rhopalosiphum prunifolae** (Fitch). (**R. pseudoavenae** Patch). Argentina.
  - **Schizaphis graminm** (Rondani). **(Toxoptera)**. Argentina.
- *Tulipa sp.* (Tulipan).
  - **Aphis rumicis** L. Argentina.
  - **Aulacorthum eumorphum** Blanchard. Argentina.
  - **Brachycaudus tulipae** (B. d. Fonsc.). Argentina.
  - **Macrosiphum solanifolii** (Ashmead). Argentina.
  - **Myzus persicae** (Sulzer). Argentina.
  - **circumflexus** Buckton. Argentina.
- Tulipán Véase *Tulipa* sp.
- Tuya. Véase *Thuja*.
- *Typha* sp. (espadana).
  - **Hyalopterus arundinis** (Fab.). Chile, Cosmopolitan.
  - **Rhopalosiphum maidis** (Fitch). Cosmopolitan.
- *Ulmus* sp. (Olmo).
  - **Eriosoma lanigerum** (Hausmann). Argentina.
- *Umbelliferæ.*
  - **Aulacorthum pseudosolani** (Theobald). Chile. **(Myzus.)**
- *Urtica* sp. (Ortiga).
  - **Brachycaudus helichrysi** (Kalt.). Argentina. **(Aphis.)**
  - **Macrosiphum edrossi,** n. sp. Peru.
  - **solutum** Blanchard. Argentina.
- *Urtica urens* L. (Ortiga).
  - **Myzus persicae** (Sulzer). Argentina.
- *Vernonia* sp.
  - **Aphis gossypii** Glover. Argentina.
  - **Macrosiphum griersoni** Blanchard. Argentina.
- *Viburnum tinus* L. (Laurel tino).
  - **Toxoptera aurantii** (B. d. Fonsc.). Argentina.
- *Vicia faba* L. (Haba).
  - **Aphis fabae** Scopoli. Argentina.
  - **medicaginis** Koch. Argentina, Peru.
  - **Macrosiphum solanifolii** (Ashmead). Argentina.
- Vid. Véase *Vitis vinifera* L.
- *Vigna luteola* (Jacq.).
  - **Picturaphis vignaphilus** Blanchard. Argentina.
- *Vinca major* L.
  - **Aulacorthum eumorphum** Blanchard. Argentina.
  - **Myzus circumflexus** Buckton. Argentina.
  - **persicae** (Sulzer). Argentina.

Viola odorata L. (Violeta).
  Idiopterus violae (Pergande). Argentina.
Violeta. Véase *Viola odorata* L.
Vitis vinifera L. (Uva).
  Aphis ampelophila Blanchard. Argentina.
    gossypii Glover. Argentina.
    illinoisensis Shimer. Argentina.
  Viteus vitifolii (Fitch). (**Phylloxera**). Argentina, Brazil, Peru.
Walnut, English. See *Juglans regia* L.
Watsonia sp.
  Macrosiphum solanifolii (Ashmead). Argentina.
Wedelia glauca (Ort.).
  Macrosiphum lizerianum Blanchard. Argentina.
Xanthium sp. (Abrojo).
  Anuraphis xanthii Del Guercio. Argentina.
Yerba mate. Véase *Ilex paraguayensis* Bonop.
Zahnia. Véase *Holcus halepensis* (L.).
Zanahoria. Véase *Daucus carota* L.
Zapallo. Véase *Cucurbita* sp.
Zea mays L. (Maiz).
  Aphis gossypii Glover. Argentina.
  Rhopalosiphum maidis (Fitch). (**Aphis**). Argentina, Brazil, Peru, Trinidad Island.
    prunifolae (Fitch). [**R. pseudoavenae** (Patch)]. Argentina, Peru.

SELECTED BIBLIOGRAPHY

Allen, N., and P. K. Harrison

1941. The turnip aphid in the southern states and methods for its control. *United States Department of Agriculture Farmers' Bulletin*, no. 1863, pp. 1–10, 8 figs.

Anderson, T. J.

1915. Report on the Entomological Laboratory for the year ending 31st March, 1914. *Annual Report of the Department of Agriculture of British East Africa*, 1913–1914, pp. 52–83.

Averill, A. W.

1945. Index to genera and species of food plants. Supplement to *Catalogue of the Aphids of the World. University of Maine Agricultural Experiment Station Bulletin*, no. 393–S, pp. 1–50.

Baker, A. C.

1915. The woolly apple aphis. *United States Department of Agriculture Annual Report*, no. 101, pp. 1–56.

1917. Life history of *Macrosiphum illinoisensis*, the grapevine aphis. *Journal of Agricultural Research*, vol. 11, pp. 83–90.

1920. Generic classification of the hemipterous family Aphididae. *United States Department of Agriculture Bulletin*, no. 826, pp. 1–109, pls. I–XVI, 1 fig. Professional paper.

Baker, A. C., and W. F. Turner

1916. Rosy apple aphis. *Journal of Agricultural Research*, vol. 7, pp. 321–344.

1919. Apple-grain aphis. *Journal of Agricultural Research*, vol. 18, pp. 311–324.

Baker, J. McV.

1934. Algunos afidos Mexicanos (Some Mexican aphids). *Anales del Instituto de Biologia*, Tomo V., no. 3, pp. 209–222.

Blanchard, E. E.

1922a. Aphid notes. *Physis*, vol. 6, pp. 43–58, figs. 15–20.

1922b. Aphid notes. *Physis*, vol. 5, pp. 184–214, figs. 1–14.

1923a. Aphid notes. *Physis*, vol. 7, pp. 24–25, figs. 21–30.

1923b. A new aphidian tribe from Argentina. *Physis*, vol. 7, pp. 120–125, fig. 1–2.

1925. Aphid notes. *Physis*, vol. 8, pp. 12–22, figs. 1–5.

1926. Aphid notes. *Physis*, vol. 8, pp. 324–337, figs. 36–41.

1932. Aphid miscellanea. *Physis*, vol. 11, pp. 19–36, figs. 1–17.

1935. Aphid miscellanea, Part II. *Physis*, vol. 11, pp. 366–383, figs. 10–17.

1936. Identificacion microscopia de los pulgones (Aphididae) que invaden los frutales de la Republica Argentina. *Revista Argentina de Agronomia*, vol. 3, no. 1, pp. 27–34, figs.

1939. Los afidoideos Argentinos. *Physis*, vol. 17, pp. 857–1003, figs. 1–20.

1940. Descripcion de un nuevo afidiino Argentino, util para la Agricultura. *Revista Museo Nacional de Historia Natural*, vol. 44, pp. 45–48.

1944. Descripciones y Anotaciones de afidoideos Argentinos. *Acta Zoologica Lilloana* II; pp. 15–62, figs. 1–13.

1945. Primer supplemento al estudio sistematico de los afidos argentinos (Resumen). *Reuniones Argentinas de Agronomia*, vol. (2a), p. 105. (Not available to author.)

BÖRNER, C.

1952. Europae centralis aphides. Die Blattläuse Mittereuropas. Namen, Synonyme, Wirtspflanzen, Generationzyklen. Pp. 1–259. Kurt Branco, Weimar (nicht Buchandel).

BÖRNER, C., and F. A. SCHILDER

1932. Aphidoidea, Blattläuse. *In* Handbuch der Pflanzenkrankheiten. Pp. 551–715, figs. 273–392. Paul Parey, Berlin.

CHRISTENSEN, JORGE R.

1937. Toxoptera graminum Rondani. "El pulgón verde de los cereales." Pp. 1–12, 1 fig.

CHRISTÓBAL, U. L.

1946. El problema del "Pulgon Verde" de los cereales en la Argentina. *Argentina. Ministerio de Agricultura de la Nacion, Instituto de Sanidad Vegetal, Buenos Aires*, ano II, ser. B, no. 4, pp. 1–24, 15 figs.

DAVIDSON, J.

1923. Bilogical studies of *Aphis rumicis* Linn. *Annals of Applied Biology*, vol. 10, pp. 35–54.

DAVIS, J. J.

1914. The oat aphis. *United States Department of Agriculture Bulletin*, no. 112, pp. 1–16.

1915. The pea aphis with relation to forage crops. *United States Department of Agriculture Bureau of Entomology Bulletin*, no. 276, pp. 1–67, 17 figs. (Professional paper.)

DAVIS, J. J., and A. F. SATTERTHWAIT

1916. The false cabbage aphis. *Purdue University Agricultural Experiment Station Bulletin*, no. 185, pp. 915–939.

DEL GUERICO, G.

1908. *Aphis Taveresi*. Broteria, vol. 7, p. 143.

DICKSON, R. C., R. A. FLOCK, and M. McD. JOHNSON

1948. Orange tree quick decline. Insects in citrus plantings studied as possible carriers. *California Agriculture*, vol. 2, no. 12, pp. 3, 13, 3 figs.

ESSIG, E. O.

1911a. Aphididae of southern California VII. *Pomona College Journal of Entomology*, vol. 3, pp. 524–557, figs. 169–186. September.

1911b. Aphididae of Southern California VIII. Plant lice affecting the citrus trees. *Pomona College Journal of Entomology*, vol. 3, no. 4, pp. 586–603, figs. 191–196. December.

1938a. The ornate aphid, new to North America. *Pan-Pacific Entomologist*, vol. 14, pp. 92–95, fig. 1.

1938b. Aphids feeding on celery in California. *Hilgardia*, vol. 11, pp. 459–492, figs. 1–12.

1944. A new aphid on Guayule and notes on other species of *Cerosipha*. *Hilgardia*, vol. 16, pp. 177–184, figs. 1–6.

1947. Aphids feeding on violaceous plants in California. *Hilgardia*, vol. 17, no. 18, pp. 597–617, figs. 1–7.

1948a. Mounting aphids and other small insects on microscopic slides. *Pan-Pacific Entomologist*, vol. 24, no. 1, pp. 9–22, 1 fig.

1948b. The most important species of aphids attacking cruciferous crops in California. *Hilgardia*, vol. 18, no. 11, pp. 407–422, figs. 1–5.

1949. Aphids in relation to quick decline and tristezia of citrus. *Pan-Pacific Entomologist*, vol. 25, no. 1, pp. 13–23.

ESSIG, E. O., and S. I. KUWANA

1918. Some Japanese Aphididae. *Proceedings of the California Academy of Sciences*, 4th ser., vol. 8, no. 3, pp. 35–112, figs. 1–40. July 9.

FENNAH, R. G.

1942. The citrus pests investigation in the Windward and Leeward Islands, British West Indies, 1937–1942. *Memoirs of the Imperial College of Tropical Agriculture*, Trinidad, 1942, pp. 1–66, 9 pls., 20 references.

FORBES, S. A.

1884. *Chaitophorus flavus* Forbes. (Original description). Thirteenth Report of the State Entomologist, State of Illinois, May 31, p. 42.

FULLAWAY, D. T., and N. L. H. KRAUSS

1945. Aphididae. *In* Common Insects of Hawaii. Pp. 62–65, pl. 4, figs. 11–18, 21. Tongg Publishing Company, Honolulu, T. H.

GILLETTE, C. P., and M. A. PALMER

1931–1934. The Aphididae of Colorado. *Annals of the Entomological Society of America:* I, vol. 24, pp. 827–934, figs. 1–100, 1931: II, vol. 25, pp. 369–496, figs. 101–208, 1932: III, vol. 27, pp. 133–255, figs. 209–333, 1934. Host index, general index.

GLOVER, T.

1855. Insects injurious and beneficial to vegetation. Report of the United States Commissioner of Patents for the year 1854, p. 62.

GÖLDI, E. A.

1855. Studien Blattläus *(Schizoneura lanigera* Hausm.; *Myzoxylus mali)*. Druck und Verlag von Friederich Rothermel, Schaffhausen. Pp. 1–28, taf. 1–3.

GOOT, P. VAN DER

1912. Über einige wahrscheinlich neue blattlausarten aus der Sammlung des Naturhistorischen Museums Hamburg. *Mitteilungen Naturhistorisches Museum Hamburg*, vol. 29, pp. 273–284, figs. 1–4.

GRIOT, M.

1949. Los enemigos naturales del pulgon verde de los cereales. *Argentina Ministerio de Agricultura y Ganadería*, ser. A, no. 48, pp. 1–29.

GOWDEY, C. C.

1926. Catalogus insectorum Jamaicensis. *Entomological Bulletin of the Department of Agriculture*, Jamaica, no. 4, pt. I; pp. 1–114; pt. II; pp. 1–11.

GUIDO, A. S., and E. C. JAHN

1946. El pulgon verde los cereales del Uruguay. *Revista Facultad Agronomica*, no. 41, pp. 1–48, figs. 1–12.

HARRIS, MOSES

1776. Exposition of English insects. London, Pp. 66–67, pl. 13, fig. 5.

HAYWARD, KENNETH J.

1944a. Los pulgones o afididos. Estación Experimental Agricola de Tucumán Circular, no. 129 (632.75 : 632.9), pp. 4–7, 4 figs.

1944b. El pulgon amarilla de la cana de azucar (*Sipha flava* (Forbes)) en Tucumán. *Estacion Experimental Agricola de Tucumán Circular*, no. 125 (632.75:633.61 (824.5) (633.61–2.75 (824.5)), pp. 3–8, 3 figs.

HEMPEL, A.

1901. A preliminary report on some new Brazilian Hemiptera. *Annals and Magazine of Natural History*, ser. 7, vol. 8, pp. 383–391.

HERRICK, G. W. and J. W. HUNGATE

1911. The cabbage aphis. *Cornell Agricultural Experiment Station Bulletin*, no. 300 pp. 717–746, figs. 286–292. Bibliography.

HILLE RIS LAMBERS, D.

1939. Contributions to a monograph of the Aphididae of Europe. II. The genera *Dactynotus* Rafinesque, 1818; *Microsiphum* Passerini, 1860; *Masonaphis*, nov. gen.; *Pharalis* Leach, 1926. *Temminckia*, vol. 4, pp. 1–134, 23 pls.

1947. Contributions to a monograph of the Aphidadae of Europe. *Temminckia*, vol. 7, pp. 247–254, pl. 13, fig. 5.

HORSFALL, J. L.

1924. Life history studies of *Myzus persicae* Sulzer. *Pennsylvania State College of Agriculture Experiment Station Bulletin*, no. 185, pp. 1–16, 1 fig.

1925. The life history and bionomics of *Aphis rumicis*. *University of Iowa Studies*, vol. 21, no. 2, pp. 1–57.

HOTTES, F. C. and T. H. FRISON

1931. The plant lice, or Aphididae of Illinois. *Bulletin of the Illinois Natural History Survey*, no. 19, pp. 121–447, 336 figs., 10 plates.

JACOBS, F. H.

1947. An account of a black aphid, *Doralis fabae* (Scop.) subsp. *armata* (Hausmann), found on *Digitalis purpurea* L. *Bulletin of Entomological Research*, vol. 37, pt. 3, pp. 431–437, figs. 1. References.

JONES, M. G.

1942. A description of *Aphis (Doralis) rumicis* L. and comparison with *Aphis (Doralis) fabae* Scop. *Bulletin of Entomological Research*, vol. 33, p. 5.

JONES, THOS. H.

1915. Aphides or plant-lice attacking sugar-cane in Porto Rico. *Porto Rico Commissioner of Agriculture Bulletin*, vol. 11, p. 1–19.

JONES, THOS. H. and C. P. GILLETTE

1918. Life history of *Pemphigus populi-transversus*. *Journal of Agricultural Research*, vol. 14, pp. 577–594.

KENNEDY, J. S. and C. O. BOOTH

1950. Methods of mass rearing and investigating the host relations of *Aphis fabæ* Scop. Annals of Applied Biology, vol. 37, no. 3, pp. 451–470.

1951. Host alternation in *Aphis fabæ* Scop. I. Feeding preferences and fecundity in relation to age and kind of leaves. [*Review of Applied Entomology*, Ser. A, vol. 39, no. 6, pp. 198–199, 1951.] Original in *Annals of Applied Biology*, vol. 38, no. 1, pp. 25–64, 7 figs., 22 references.

KIRKALDY, G. W.

1907. On some peregrine Aphidae in Oahu. Hem. *Proceedings of the Hawaiian Entomological Society*, vol. i, pp. 99–102.

KOCH, C. L.

1854–1857. Die Pflanzenlause, Aphiden, getreu nach dem Leben abgebildet und beschrieben. Nurnberg, Lotzbeck. Pp. viii + 335, 54 pls. in color.

LAING, F.

1927. An interesting aphid (new species) and a coccid from the Argentine Republic. *Revïsta de la Sociedad Entomológica Argentina*, vol. 2, no. 4, pp. 23–26, 1 fig.

1932. A new aphid pest of violets (*Myzus ornatus* n. sp.). *Entomologists' Monthly Magazine*, vol. 68, pp. 52–53.

LARSSON, S. G.

1941. *Aphis fabæ* and its host plants in Denmark. *Tidsskrift for Planteavl*, vol. 46, pp. 298–323 (in Danish). Reviewed in *Review of Applied Entomology*, ser. A, vol. 32, p. 69, 1944.

LIEBERMANN, JOSÉ

1930. Consideraciones definitivas acerca de la lucha biólogica contra las plagas de la humanidad. Un nuevo enemigo natural del *Aphis nerii* Boyer, el terrible pulgón del laurel rosa. *Physis*, vol. 10, no. 35, pp. 166–170.

LIMA, A. DA COSTA

1942. Aphidoidea. *In Insetos do Brasil*. Tomo 3, capítulo 23, pp. 112–175, figs. 121–152. Bibliography on pp. 161–175.

LÓPEZ CHRISTÓBAL, UBALDO

1937a. Los aphidos de los cereales. Pp. 11–22, figs.

1937b. Los pulgones verdes de los cereales y sas parasitos. *Boletín del Laboratorio de Zoologia Agricola La Plata*, vol. 3, pp. 1–5.

1942. El pulgón verde de los cereales, *Toxoptera graminum* Rondani. Lucha biólogica quimica, mecánica. *Anales de la Sociedad Rural Argentina*, vol. 76, no. 2, pp. 186–192; Suelo Argentina, vol. 3, pp. 460–462, 1944.

1943. El pulgon verde de los cereales (*Schizaphis graminum* [Rondani] Blanchard i. l.). *El Campo*, vol. 29, no. 344, pp. 40–41, 43.

MASON, P. W.

1925. A revision of the insects of the aphid genus Amphorophora. *United States National Museum Proceedings*, vol. 67, pp. 1–92.

1927. Fauna Sumatrensis; Aphidae. *Supplementa Entomologica*, vol. 15, pp. 86–90.

1937. A new root aphid. *Proceedings Entomological Society of Washington*, vol. 39, no. 6, pp. 166–7, fig. 1.

1940. A revision of the North American aphids of the genus Myzus. *United States Department of Agriculture Miscellaneous Publications*, vol. 371, pp. 1–30, figs. 1–7.

MATUS, M. D.

1922. El pulgón lanigero de los manzanos (*Schizoneura lanigera* Hausm.), su destrución por medio de la lucha biologica con el *Aphelinus mali*. *Anales de la Sociedad Rural Argentina*, vol. 57, pp. 720–723, figs.

MAXSON, ASA C.

1920. Principal insect enemies of the sugar beet in the territories served by the Great Western Sugar Company. Great Western Sugar Co., Denver, Colo., pp. vii + 157.

MORDVILKO, A.

1930. Aphids of the subtribe Hormaphidina. *Comptes Rendus Académie des Sciences de l'URSS.*, p. 277. (*Brasilaphis bondari* Mord.).

MOREIRA, C.

1925. Pulgoes do Brasil. Ministerio da Agricultura, Industria E. Commercio. *Instituto Biologico de Defesa Agricola Bol.*, no. 2, pp. 1–34, figs.

PALMER, M. A.

1939. Two unusual species of aphids infesting wheat. *Journal of Economic Entomology*, vol. 32, no. 2, pp. 345–346, figs. 1–2.

PATCH, E. M.

1907. The potato plant louse. *Maine Agricultural Experiment Station Bulletin*, no. 147, pp. 235–257.

1912. Aphid pests of Maine. *Maine Agricultural Experiment Station Bulletin*, no. 202, pp. 159–178.

1913. Aphid pests of Maine: Part II. *Maine Agricultural Experiment Station Bulletin*, no. 213, pp. 73–92.

1914. Maine aphids of the rose family. *Maine Agricultural Experiment Station Bulletin*, no. 233, pp. 253–280, figs. 89–97.

1915a. Pink and green aphid of potato. *Maine Agricultural Experiment Station Bulletin*, no. 242, pp. 205–223.

1915b. The pond lily aphid as a plum pest. *Science*, vol. 42, p. 164.

1915c. Two clover aphids. *Journal Agricultural Research*, vol. 3, pp. 431–433.

1916. Elm leaf rosette and woolly aphid of the apple. *Maine Agricultural Experiment Station Bulletin*, no. 256, pp. 329–344.

1917a. Eastern aphids, new or little known: Part I. *Journal of Economic Entomology*, no. 10, pp. 416–420.

1917b. The aphid of the choke cherry and grain. *Maine Agricultural Experiment Station Bulletin*, no. 267, pp. 293–297.

1919. Three pink and green aphids of the rose. *Maine Agricultural Experiment Station Bulletin*, no. 282, pp. 205–209.

1921. Rose bushes in relation to potato culture. *Maine Agricultural Experiment Station Bulletin*, no. 303, pp. 321–344.

1923. Aphididae *in* Hemiptera of Connecticut. *Connecticut State Geological and Natural History Survey Bulletin*, vol. 34, pp. 250–256, 290–311, 329–335.

1925. Potato aphids. *Maine Agricultural Experiment Station Bulletin*, no. 323, p. 9–36.

1927. The pea aphid in Maine. *Maine Agricultural Experiment Station Bulletin*, no. 337, pp. 9–20.

1928. The foxglove aphid. *Maine Agricultural Experiment Station Bulletin*, no. 346, pp. 49–60.

1929. The apple aphid and the citrus aphid. *Journal of Economic Entomology*, vol. 22, pp. 698–699.

1938. Food-plant catalogue of the aphids of the world. Including the Phylloxeridae. *Maine Agricultural Experiment Station Bulletin*, no. 393, pp. 35–431.

PHILLIPS, W. J. and J. J. DAVIS

1912. Studies on a new species of Toxoptera. *United States Department of Agriculture Bureau of Entomology, Technical Series*, no. 25, pt. 1, pp. 109–174, figs. 1–14.

PIERCE, W. DWIGHT

1917. A manual of dangerous insects likely to be introduced in the United States through introductions. *United States Department of Agriculture*, Office of the Secretary, Aug. 15, 1917, pp. 1–256, figs. 1–107, pls. I–XLIX.

PIRÁN, A. A.

1946. Bibliografia Entomologica Argentina. *Ministerio de Agricultura de la Nación, Instituto Sanidad Vegetal*, Año II, ser. B., no. 5, pp. 1–144

PRETHERBRIDGE, F. R. and D. W. WRIGHT

1938. The cabbage aphis (*Brevicoryne brassicæ* L.). *Journal Ministry of Agriculture*, pp. 140–148, 2 refs.

RECORD, SAMUEL J., and ROBERT W. HESS

1943. Timbers of the new world. *Yale University Press*. New Haven, Connecticut. Pp. xv + 640 (Citation p. 10).

Reed, Carlos S.

1910. Los Aphideos que atacan a los árboles frutales en la provincia de Mendoza. *La Viticultura Argentina*, vol. 1, pp. 35–42, figs.

Reiniger, C. H.

1942. (1941) Contribuição ao estudo dos possivies insetos vetores de virus dos "Citri no Brasil." *Boletim da Escola Nacional da Agronomia*, 1941, no. 2, Art. 6, pp. 225–245.

Rivnay, E.

1937. Moisture as the factor affecting wing development in the citrus aphid, *Toxoptera aurantii* Boy. *Bulletin of Entomological Research*, vol. 28, pp. 173–9, figs. 1–7.

Roepke, W.

1928. Über die Franssenschen Untersuchungen an schwarzen Blattläusen der *Aphis fabæ*-Gruppe in Holland. *Stettiner Entomologische Zeitung*, vol. 89, pp. 1–30.

Sampson, Wilson

1946. A generic classification of California aphids by means of first instar nymphs. *University of California Publications in Entomology*, vol. 1, no. 12, pp. 365–402, 57 figs. Bibliography.

Severin, H. H. P., and C. M. Tompkins

1950a. Aphid transmission of severe mosaic virus of annual stock. *Hilgardia*, vol. 20, pp. 93–102, pls. 1–4.

1950b. Transmission of radish-mosaic virus by aphids. *Hilgardia*, vol. 20, no. 11, pp. 191–198, pls. 1–7.

1950c. Aphid transmission of a mosaic virus and symptoms of other virus diseases of *Primula obconica*. *Hilgardia*, vol. 20, no. 15, pp. 279–288, pls. 1–8, (1 colored).

Shimer, H.

1866. A new grape aphis. *Prairie Farmer*. Chicago, Ilinois. Nov. 17, p. 316.

Silvestri, F.

1934, 1939. Aphididae *in* Compendio di Entomologia Applicata, Tipografia Bellavista, Portici, Italy. Pt. 1, pp. 1–448, figs. 1–414, 1934; pt. 2, pp. 449–974, figs. 415–878, 1939. Aphididae pp. 412–618, figs. 318–588.

Smith, E. R.

1890. The black peach aphis. *Entomologica Americana*, vol. 6, pp. 101–103.

Smith, Kenneth M.

1937. *Aphididae. in* A Textbook of Plant Virus Diseases. Blakiston's, Philadelphia, Pennsylvania. Pp. 15, 38, 45, 54, 122, 157, 168, 175, 418, 427, 505–548, 556, figs. 91–101. [Total pagination: x + 615, 101 figs.]

Smith, L. B.

1919. The life history and biology of the pink and green aphid (*Macrosiphum solanifolii* Ashmead). *Virginia Truck Experiment Station Bulletin*, no. 27, pp. 27–79.

SMITH, LESLIE M.

1936. Biology of the mealy plum aphid, *Hyalopterus pruni* (Geoffroy). *Hilgardia*, vol. 10, no. 7, pp. 167–209, 12 figs. 1 pl.

1937a. Growth, reproduction, feeding, and wing development of the mealy plum aphid in relation to climate factors. *Journal of Agricultural Research*, vol. 54, no. 5, pp. 345–364, 9 figs.

1937b. Control of the mealy plum aphid. *University of California Agricultural Experiment Station Bulletin*, no. 606, pp. 1–34, 11 figs.

SOLIMAN, L. B.

1927. A comparative study of the structural characters used in the classification of the genus *Macrosiphum* of the family APHIDIDAE, with special reference to the species found in California. *University of California Publications in Entomology*, vol. 4, no. 6, pp. 89–158, figs. 1–77.

SQUIRE, F. A.

1937. Notes on the yellow aphis of sugar-cane *Sipha flava* Forbes. *Tropical Agriculture*, vol. XIV, no. 1, pp. 3–4, 1937. (*Review of Applied Entomology*, Ser. A., vol. 25, 252–253, 1937).

SWAIN, A. F.

1919. A synopsis of the Aphididae of California. *University of California Publications in Entomology Technical Bulletin*, vol. III, no. 1, pp. 1–221, pls. 1–17, Nov. 1.

SYMES, C. B.

1924. Notes on the black citrus aphis. *Rhodesia Agricultural Journal*, vol. xxi, nos. 5 and 6, pp. 612–626 + 725–732, 2 pls., 7 figs. Salisbury, October and December.

TATE, H. D., and S. R. VANDENBERG

1939. Transmission of sugar cane mosaic by aphids. *Journal of Agricultural Research*, vol. 59, pp. 73–80, 8 refs.

TAYLOR, L. R.

1950. Synchronous movement of *Aphis fabae* Scop. (Hem. APHIDIDAE). *Entomologists' Monthly Magazine*, series 4, no. 122 [no. 1029], p. 52.

THEOBALD, F. V.

1913–1914. African Aphididae. *Bulletin of Entomological Research*, no. 4, pp. 313–337.

1926–1927–1929. The plant lice or Aphididae of Great Britain. Hadley Bros. London, England. Vol. 1, pp. 1–372, 196 figs., 1926; vol. II, pp. 1–411, 182 figs., 1927; vol. III, pp. 1–364, 213 figs., 1929.

THOMAS, CYRUS

1878 (1877). A list of the species of the tribe Aphidini, Family Aphididae, found in the United States, which have been heretofore named, with descriptions of some new species. *Bulletin Illinois State Laboratory of Natural History*, vol. I (No. 2), Art. 1, pp. 3–16. Printed December 13, 1877, distributed 1878.

WEBSTER, F. M. and W. J. PHILLIPS

1921. The spring grain aphis or "green bug." *United States Department of Agriculture* Bureau of Entomology Bulletin 110, pp. 1–153.

WOLCOTT, G. N.

1922. Afidos de importanicia economica en Puerto Rico. *Departamento de Agricultura Y Trabajo, Estación Experimental Insular,* Circ. 59, pp. 1–11, fig. 9.

1928. Los Afidos que afectan la Industria Azucarera del Peru. *La Vida Agricola,* vol. 59, pp. 877–886, 1 fig. (*Review of Applied Entomology,* vol. 17, p. 99–100, 1929).

1933. An economic entomology of the West Indies. *Entomological Society of Puerto Rico,* San Juan. Pp. xxiii + 688, 111 figs.

1936. Aphididae. *The Journal of Agriculture of the University of Puerto Rico,* vol. 20, pp. 111–119.

1948. The insects of Puerto Rico. *Journal of Agriculture of the University of Puerto Rico,* vol. xxxii, no. 1, pp. 1–224. (Many illustrations unnumbered). APHIDIDAE: pp. 146–156.

YOTHERS, W. W. and F. R. COLE

1924. The citrus aphid—*Aphis spiraecola* Patch. *Florida Grower,* vol. 30, pp. 6, 15, 17.

ZIMMERMAN, E. C.

1948. Superfamily APHIDOIDEA. *In* Insects of Hawaii, vol. 5, pp. 53–131, figs. 25–85.

PROCEEDINGS

OF THE

CALIFORNIA ACADEMY OF SCIENCES

Fourth Series

Vol. XXVIII, No. 4, pp. 165-246; 28 text figs. January 7, 1954

NATURAL HISTORY OF THE PALLID BAT, *ANTROZOUS PALLIDUS* (LeConte)

By
ROBERT T. ORR
Curator of Ornithology and Mammalogy
California Academy of Sciences

INTRODUCTION AND ACKNOWLEDGMENTS

So little is known regarding the natural history of many of our common species of North American bats that it is frequently difficult or impossible to provide satisfactory answers to seemingly simple questions on the subject. These voids in our knowledge do not reflect a lack of scientific interest in bats but rather have resulted from the technical difficulties involved in studying these animals.

Almost every above-ground movement of many kinds of diurnal mammals can be noted by careful observers. The use of live traps and of marking has provided us with considerable information on the activities of many nocturnal, terrestrial species. Who, however, can accurately state how far a bat flies in the evening after it emerges from its daytime retreat? So far as the observer is concerned the animal's identity is usually lost in the gloom of twilight within a matter of seconds. The distance that it travels in search of food, whether a few hundred yards or some miles, must largely remain a matter for conjecture until more advanced techniques for study are developed.

Vaguely aware of some of the difficulties involved in a project concerning chiropteran life history, the writer began such an undertaking in May, 1947. The pallid bat, *Antrozous pallidus* (LeConte), was the species selected for this purpose for several reasons. It is relatively common in central California. It can easily be kept in captivity. It is sufficiently large and distinctive in appearance to be readily recognizable in the field, even at night in the beam of a flashlight. The results obtained to date are presented in this paper. These include field observations, information derived from studies of bats in captivity, and relevant data extracted from the literature. It is felt that there are still many voids in our knowledge of events concerning the natural history of this one species but it is to be hoped that future studies may solve some of these problems.

Many persons contributed to this project. I wish to thank Dr. Robert C. Miller, director of the California Academy of Sciences, for the funds and facilities provided by that institution which made this undertaking possible. I am particularly indebted to Miss Mary Louise Perry for her painstaking care of captive animals during a period of over four years and for accurately recording and interpreting data obtained from laboratory studies. I am also especially grateful to Mr. Eben McMillan for his enthusiastic cooperation in locating bat colonies in San Luis Obispo and Kern counties, California, and for his very active participation in much of the field work. For the identification of many ectoparasites and of insects used as food by bats I wish to thank Dr. Edward W. Baker, United States Department of Agriculture, Washington, D. C.; Professor G. F. Ferris, Stanford University; Mr. Robert Holdenried, United States Public Health Service, Santa Fe, New Mexico; Dr. Glen M. Kohls, United States Public Health Service, Hamilton, Montana; Mr. Frank Prince, United States Public Health Service, San Francisco, California; Dr. Edward S. Ross, Dr. Edward L. Kessel, and the late Dr. Edwin C. Van Dyke of the Department of Entomology, California Academy of Sciences. For permission to borrow or study specimens under their care I wish to thank Dr. Seth B. Benson, Museum of Vertebrate Zoology, University of California; Dr. William H. Burt, Museum of Zoology, University of Michigan; Dr. David H. Johnson, United States National Museum; and Dr. Colin C. Sanborn, Chicago Natural History Museum. Others who contributed to this study include Mr. Lionel Berryhill, Mr. Sterling Bunnel, Miss Laura Grainger, Mrs. J. Gordon Irving, Mrs. Berta B. Kessel, Mr. Hugh B. Leech, Mr. Ian McMillan, Mrs. Dorothy B. Orr, Mr. Frank L. Rogers, Dr. Charles G. Sibley, Mr. Leon E. Salanave, and Mr. M. Woodbridge Williams.

METHODS

A number of summering colonies of pallid bats were known to the writer in or fairly close to the San Francisco Bay region. Most of the field work, however, was concentrated in eastern San Luis Obispo and western Kern counties because conditions in that region seemed highly favorable for bats of this species, judging from their abundance, and because the environmental changes resulting from human usage had been less there than in many parts of California.

Thirty-one days, devoted primarily to obtaining data relevant to this species, were spent in the field as follows:

May 9–11, 1947, San Luis Obispo and Kern counties.
August 9–10, 1947, Humboldt County (M. L. Perry).
September 19–22, 1947, San Luis Obispo and Kern counties.
February 27–March 1, 1948, Monterey, San Luis Obispo, and Kern counties.
June 5–9, 1948, San Luis Obispo and Kern counties.
April 1–4, 1949, Monterey, San Luis Obispo, and Kern counties.
October 21–24, 1949, Monterey, San Luis Obispo, and Kern counties.
January 22, 1950, Marin County.
April 13–16, 1951, San Luis Obispo and Kern counties.
June 13, 1952, Santa Clara County.

Although all of the field observations made on *Antrozous pallidus* were within the range of the race *pacificus*, as given by Grinnell (1933), occasional references are made to published reports concerning the natural history of other geographic forms of this species.

Pallid bats were maintained in captivity during the entire period of this study. Most of the wild-taken individuals were released, with United States Fish and Wildlife Service bird bands attached to their forearms, from 10 to 13 months after capture. Such releases were made either at the original place of capture or, for experimental purposes in an attempt to study homing instinct, at some other locality within the same general region in which field studies were made.

As a rule bats were captured at their daytime retreats, usually with the aid of insect nets and long-handled forceps. They were transported to the laboratory in cages 16 inches wide, 16 inches high, and 12 inches deep, made of plywood and quarter-inch hardware cloth, with sliding doors at the back. At the California Academy of Sciences bats were housed in several sizes of cages for various purposes. Small retaining cages of the type just mentioned were used for the confinement of females with newly born young to facilitate studies on behavior and growth, for isolating certain individuals, and in enforced dormancy experiments. A larger cage, 48 inches wide, 38 inches high, and 42 inches deep, made of quarter-inch hardware cloth on a wooden frame, was used for small colonies kept in the laboratory. This was sufficiently large to permit limited flight. Two large flight cages, 4 feet wide, 8 feet high, and 10 feet deep, that had previously been used as aviaries (for detailed description see Orr, 1945, p. 179) on the roof of the Academy's North American Hall, served to maintain small colonies of bats out-of-doors.

The smaller cages were kept darkened during the day by hanging burlap or paper over the screened side or by placing this side next to a wall. In the larger cages bricks, boards, or small boxes provided daytime retreats for the bats. Each occupied cage was provided with food and water daily, except on week-ends. The food consisted principally of meal worms (the larvae of the flour beetle, *Tenebrio molitor*) which were killed by momentarily scalding them before they were placed in the feeding dishes in the late afternoon. Since, on occasion, as many as 10,000 meal worms were used weekly, it was not found practical to raise them. They were secured from the Sure-Bite Live Bait Company in Torrance, California.

Toward the end of this project it was found more practical, economical, and satisfactory from the standpoint of maintaining healthy captive animals, to use a food mixture recommended by Mr. Ernest P. Walker, assistant director of the National Zoological Park, Washington, D. C. This consisted of equal parts of hard-boiled egg yolk, cottage cheese, ripe banana, and meal worms, with small amounts of Jeculin, wheat germ oil, and vitamin mixture added. The ingredients were ground into a paste. It was found expedient to prepare a fairly large quantity of this food at one time, dividing it into small portions which were wrapped in wax paper and kept frozen until needed.

DESCRIPTION

The pallid bat is readily distinguished, on the basis of external characters, from all other North American bats by its combination of large size, proportionately large ears and broad wings, peculiar shape of nose, and color of pelage.

Of the 24 species of bats recorded as occurring in California (Grinnell, 1933; Constantine, 1946; Olson, 1947) only 4 approximately equal or exceed the pallid bat in general body size. These are the hoary bat (*Lasiurus cinereus* (Beauvois)), the western yellow bat (*Dasypterus ega* (Gervais)), the pocketed bat (*Tadarida femorosacca* (Merriam)), and the mastiff bat (*Molossus perotis* Schinz). The hoary bat is not often

Figure 1. The ears and eyes of the pallid bat are proportionately large. Note the serrated outer edge of the tragus. Photographed at the California Academy of Sciences, November 12, 1952.

found in the same region as the pallid bat, except in spring and autumn when the former species is migrating. Only once during this study were these two species noted together (Orr, 1950). The western yellow bat has been recorded only once from California (Constantine, 1946). The pocketed bat and the mastiff bat are both members of the family Molossidae. The former species is very rare in California, known only from the extreme southern part of the state. The mastiff bat is more widely distributed but of rather local occurrence and cannot be considered common. Furthermore, it is readily distinguished from the pallid bat by its greater size, having an average wingspread in excess of 500 millimeters.

The ears of the pallid bat are separate and large, although not as long, proportionately, as in members of the genera *Corynorhinus* and *Euderma*. In shape the pinna is roughly rhomboidal, obliquely attached at the base and rounded at the tip. When laid forward it extends considerably beyond the nose. Along the postero-lateral half of the ear there are usually 9 to 11 horizontal creases which permit the pinna to be folded back. The tragus is slender, tapering distally, rounded at the tip, and serrate along the outer edge (fig. 1). The ears are pale grayish tan in color. A narrow strip of hairs is present on the antero-dorsal rim of the pinna, extending from the base halfway to the tip. Two narrow bands of hairs, extending parallel to the long axis of the ear, are present inside the pinna.

The wings are proportionately broad with the third metacarpal only slightly longer than the fifth. Only the extreme tip of the tail extends beyond the uropatagial membrane. The flight membranes, in general, are essentially naked except those parts immediately adjacent to the body. In color they are a dark slate gray with a slight vinaceous tinge. The calcar terminates in a small but distinct lobe just short of the middle of the free edge of the uropatagial membrane. The feet are proportionately large and broad, with a few sparse hairs on the backs of the toes.

The end of the muzzle of the pallid bat is decidedly truncate with the nostrils opening forward. The rhinarium is scroll-shaped and elevated into a slight ridge above the nares. Behind the rhinarium, on either side of the muzzle, is a large, flattened, glandular swelling (fig. 2). The eyes are relatively large for vespertilionid bats.

TABLE I

Average and extreme measurements, in millimeters, of adult specimens of *Antrozous pallidus pacificus* from eastern San Luis Obispo and western Kern counties, California.

	Total length	Tail length	Hind foot	Ear from notch	Fore-arm	Wing-spread
			Males			
Average	115.9	39.6	13.3	29.1	56.3	383
Maximum	124	44	15	31	58.1	385
Minimum	111	35	11	27	53.3	382
Number averaged	15	15	15	14	10	3
			Females			
Average	118.7	42.6	13.7	30.1	57.9	380.3
Maximum	130	49	16	33	60.2	393
Minimum	107	37	12	26	54.2	370
Number averaged	22	22	21	22	13	9

Pelage: The fur of the pallid bat is not dense and is of moderate length and medium texture. The hairs on the dorsal surface of the body are, for the most part, longer and more widely separated from one another than are those on the ventral surface. The area between the

Figure 2. Large, glandular swellings are situated on either side of the muzzle of the pallid bat, immediately behind the scroll-shaped rhinarium. Photographed at the California Academy of Sciences, December 10, 1952.

shoulders is very scantily haired. Some of the longest hairs from the back of an average adult specimen in fresh pelage measured 8 millimeters from tip to base when taut. Owing to a slight natural kinkiness, however, the actual distance from tip to base rarely exceeds 5 or 6 millimeters for the dorsal hairs and 3 to 4 millimeters for hairs on the ventral parts of the body.

The hairs on the dorsal areas of the head and body are bicolored. In specimens of *Antrozous pallidus pacificus* Merriam from San Luis Obispo County, in fresh pelage, the distal third of these hairs is nearest Ridgway's (1912) Olive-Brown and the proximal two-thirds is nearest Cartridge Buff. The hairs on the ventral surface of the head and body are generally unicolored and, in fresh pelage, vary from a creamy white to a very pale grayish white. Occasionally some of the tips of the ventral hairs have a fuscous tinge, especially those on the posterior part of the body. In worn pelage the distal third of the hairs of the upper parts tends to become lighter, approaching Saccardo's Umber while the proximal two-thirds of these hairs becomes more yellowish than in fresh pelage. Likewise, the hairs on the ventral parts become more buffy. A certain amount of this seasonal change in pelage color, particularly on the underside of the body, appears to be adventitious, possibly because of frequent contact with urine and excrement in the roosts.

One example of albinism is known. Setzer (1950, p. 350) records an albinistic specimen of this species in the collection of the United States National Museum. It was secured by Stanley G. Jewett on February 9, 1940, 26 miles north of Las Vegas, Nevada.

Molt: There is but one molt annually in this species. This takes place during the summer months, the time of occurrence varying considerably with different individuals in the same colony. Examination of museum specimens, captive bats, and those living in the wild failed to indicate any sign of molt starting before early May or of not having begun by the end of August. Most signs of molting were to be observed during the months of June and July. Pregnancy does not appear to influence the molt. Examination of females in late stages of pregnancy on June 6, 1948, in eastern San Luis Obispo County, showed that some had not yet begun to molt while others in the same colony were either in process of molting or had already assumed new pelage.

New pelage first makes its appearance on the relatively bare area of the back, between the shoulders, and, midventrally, at the base of the neck. The new hairs on the intershoulder area radiate from a point on the middorsal line while the new hairs on the underside of the neck are arranged in the form of a whorl. Simultaneously with the appearance of new hair on these two parts of the body the skin of the back appears darkly pigmented. Following this, new hair is soon in evidence from the crown of the head to the lower part of the back and on the ventral part of the head and body. The new hairs grow more rapidly on the middorsal surface than elsewhere and appear last of all on the front of the head, sides of the neck, and rump. Examinations of study skins as well as living individuals have shown that the old fur on a particular part of the body falls out when the new fur on that area has grown out to about half of its full length. When captive molting bats were handled at this stage the old fur came out readily in clumps.

The time required to complete the molt seemingly is not very long. One captive individual was observed in the very early stages of molt on August 26, 1949. New fur was just appearing above the surface of the skin between the shoulders and on the underside of the neck. When this bat was examined 13 days later it was completely in new pelage although some of the hairs had not yet quite attained full length.

Distribution

Antrozous pallidus belongs to the family Vespertilionidae and the subfamily Nyctophilinae. The only other genus belonging to this subfamily, according to Miller (1907, p. 234) and Simpson (1945, p. 60), is *Nyctophilus* of Australia and the East Indies. The genus *Antrozous* is restricted to North America where its range extends from southern British Columbia east to Kansas and south to south-central Mexico. It has been recorded[1] in the following states or provinces: southern British Columbia (Racey, 1933, p. 18), eastern Washington (Dalquest, 1938, p. 213), parts of Oregon (Bailey, 1936, pp. 390–392), parts of California (Grinnell, 1933, pp. 93–94), western and southern Nevada (Hall, 1946, p. 164), southern and eastern Utah (Durrant, 1952, p. 60), parts of Arizona (Miller, 1897, p. 44; Swarth, 1929, p. 347; McKee, 1932, p. 71; Cahalane, 1939, p. 422), parts of New Mexico (Bailey, 1931, p. 379), southern Colorado (Warren, 1910, p. 284), southern Kansas (Hibbard, 1934, p. 227), northwestern Oklahoma (Burt, 1945, p. 309), western Texas (Bailey, 1905, p. 214), Baja California (Nelson, 1921, p. 128), Sonora (Burt, 1938, p. 27), Durango (Allen, 1903, p. 612), Nuevo Leon (Davis, 1944, p. 380), and Queretaro (Miller, 1897, p. 45). There are previously unrecorded specimens from Tamaulipas, Mexico, in the University of Michigan Museum of Zoology and it is likely that further collecting will disclose the presence of this genus in a number of other states in northern and central Mexico as well as in southern Idaho.

Within the range of the genus there are two currently recognized species, *Antrozous pallidus* and *A. bunkeri* Hibbard. These two forms are very closely related and likely will prove to be conspecific. So far as known, *A. bunkeri* has been recorded only from the type locality in southern Kansas (Hibbard, 1934) and from one locality in northwestern Oklahoma (Burt, 1945). *Antrozous pallidus,* whose distribution is much more extensive, is represented by four currently recognized geographic races whose ranges are approximately as follows: *pallidus,* southeastern California and northeastern Baja California east to Colorado and Texas and south to south-central Mexico; *cantwelli,* southern British Columbia and eastern Washington south to northeastern California and northwestern Nevada; *pacificus,* northwestern Oregon south to northwestern Baja California; *minor,* central to southern Baja California.

Antrozous pallidus is primarily a species of the Lower and Upper Sonoran life zones. In parts of Oregon and California, however, it ranges well up into the Transition Zone, locally, and to the south, in parts of Mexico occurs in the Arid Tropical Zone. It has an altitudinal

---

[1] The references cited are not necessarily the first published records but, wherever possible, those that give the most complete distributional accounts for each state or province concerned.

range known to extend from –178 feet in Death Valley, California (Grinnell, 1933, p. 94), to at least 6700 feet in the Quinn Canyon Mountains, Nevada (Hall, 1946, p. 166). These altitudinal extremes are both within the range of the race *pallidus.* In central California, however, the writer has records of *Antrozous p. pacificus* from essentially sea level at Inverness, Marin County, to 5000 feet at Long Barn, Tuolumne County.

HABITAT

No attempt is made here to give a general description of the habitat of the pallid bat since environmental conditions vary so much throughout different parts of its rather extensive range. To facilitate a better understanding of the requirements of members of this species, however, some of the situations in which they have been observed are described. These include coniferous forests of several different types, nonconiferous woodland, brushy terrain, rocky canyon, open farm land, and desert. Suitable daytime retreats or roosts, of course, are essential for the occurrence of these bats in any region. It is possible that the presence of available fresh water nearby also is necessary.

Fairly conclusive evidence was obtained indicating that pallid bats occur in Richardson Grove State Park, Humboldt County, California. This grove of redwoods *(Sequoia sempervirens)* is close to the Eel River and there is open country nearby where bats of this species might forage at night. A torpid pallid bat was found at an abandoned cabin in a dense redwood forest in Mill Valley, Marin County, California, on January 15, 1950.

At various times in 1948, 1949, and 1950 Mr. M. Woodbridge Williams noted pallid bats in or around his home in Inverness, Marin County. An individual was captured here on November 7, 1948, and another in August, 1950. Much of the forest growth in the vicinity of the Williams' home is native, consisting principally of Bishop pine *(Pinus muricata)*, coast live oak *(Quercus agrifolia)*, tan oak *(Lithocarpus densiflora)*, and madrone *(Arbutus menziesii)*.

On the evening of May 29, 1939, the writer captured a pallid bat at Long Barn, 5000 feet, Tuolumne County, California. This individual flew in through an open window of a cabin situated in a forest composed principally of yellow pine *(Pinus ponderosa)*, white fir *(Abies concolor)*, and incense cedar *(Libocedrus decurrens)*. Bailey (1936, p. 390) records pallid bats associated with yellow pine in southwestern Oregon.

In San Luis Obispo and Kern counties, California, summering colonies of these bats were found either in buildings or in crevices in rock.

One group of ranch buildings inhabited by them was situated near the mouth of a small canyon which opened out onto a flat that was used for raising grain. The vegetation behind the buildings consisted largely of grasses with clumps of *Eriogonum fasciculatum* and *Artemisia californica* scattered about. There were some large cottonwood, pepper, and fig trees growing near the buildings. Permanent water, provided by a spring, was available close by. Mr. Eben McMillan found another colony of pallid bats living in the attic of a garage in the town of Shandon. There were a good many cultivated trees nearby and open grassland within a quarter of a mile.

Figure 3. Rocky outcrops provide numerous roosting sites in the form of crevices for pallid bats. Photographed near Carneros Spring, Kern County, California, May 20, 1948, by G Dallas Hanna.

Five colonies were found in natural rock crevices. Two of these colonies were located within several hundred yards of each other in a large outcrop of sandstone at the northwestern edge of the Carrizo Plain, San Luis Obispo County. Some of the rocks were 50 to 60 feet in height. Immediately surrounding the outcrop was grassland intermingled with a good many trees and shrubs including blue oak *(Quercus douglasii)*, islay *(Prunus ilicifolia)*, great-berried manzanita *(Arcto-*

staphylos glauca), black sage *(Salvia mellifera)*, California sagebrush *(Artemisia californica)*, and *Aplopappus cuneatus*. During the dry season the nearest available water was about one-half mile distant. Another colony was found in a sandstone outcrop 2½ miles northwest of Carneros Spring, Kern County. The surrounding terrain was extremely arid (fig. 3). A few low-growing shrubs, principally California sagebrush and *Eriogonum* sp., were present near the base of the rocks. Whether or not there was any water available to bats nearer than Carneros Spring was not determined. Two other colonies were found inhabiting rocky escarpments bordering a small valley through which San Juan Creek flows, 3 miles southeast of La Panza, San Luis Obispo County (fig. 4). The valley was no more than one-quarter of a mile in width. A few oaks were scattered about in the grassland and an occasional willow grew along the streamside.

Figure 4. Favorable habitat for pallid bats on the La Panza Ranch along San Juan Creek, San Luis Obispo County, California. Photographed June 9, 1948.

A number of other chiropteran species were observed in the general area inhabited by the pallid bats in San Luis Obispo and Kern counties. These included *Myotis yumanensis, M. thysanodes, M. volans, M. californicus, M. subulatus, Pipistrellus hesperus, Eptesicus fuscus, Corynorhinus rafinesquei, Tadarida mexicana*, and *Molossus perotis*.

Hall (1946, p. 163) comments that in the Carson Basin, Churchill County, Nevada, the pallid bat "frequents the edges of the basin, foraging there as well as roosting in the caves along the outcrops of rock at the foot of the hills." Burt (1934, p. 397) records this species as a common inhabitant of the lower desert regions of southern Nevada, especially around ranch houses where water and vegetation are present.

ROOSTS

During most of the spring, summer, and autumn months pallid bats are found during the daylight hours in groups or colonies generally consisting of no more than one hundred individuals and frequently composed of a considerably smaller number. The cavities or crevices which provide daytime roosts for these colonies may be in rocks, trees, or various man-made structures as has already been indicated. Irrespective of their diversity in location, all of the roosting places examined appeared to have certain features in common. All provided semidarkness, and protection from above. The ventral surface of the body of a roosting bat was always against a solid surface which was either a part of the roost or the body of another bat. Roosting pallid bats were never observed hanging freely from a horizontal surface, such as the roof of a cave, in the daytime. Some other species of bats regularly hang in this latter manner. The opening from the roosting crevice to the outside was, with one exception, at least several feet, usually much more, above the substratum, thus permitting the bats both to take flight immediately after emerging and to fly directly into the opening when returning. The opening was generally beneath the roost although when the roost was in a building it was frequently necessary for the entrance to be on a horizontal plane.

In the event that pallid bats are disturbed at their roost they frequently will leave and go to an alternative roost which is usually located nearby. The permanence of such moves is not known. In at least two instances roosts that were so vacated, as a result of disturbance, were found unoccupied during the succeeding several years. There is some indication that the shifting of a colony from one site to another is sometimes done without apparent provocation. On several occasions roosts were found to be inhabited in the spring and were left undisturbed by the observer. When examined several months later they were unoccupied. Although it is possible that these colonies were disturbed by someone in the meantime, their locations were such as to make this exceedingly improbable. Ryberg (1947, pp. 74–77) comments on similar alternative roosts used by certain species of bats in northern Europe, and Pearson, Koford, and Pearson (1952, p. 276) comment on the alternative roosts of summering colonies of *Corynorhinus.*

Since pallid bats are not primarily forest dwellers, roosts in cavities in trees are of relatively uncommon occurrence. On August 9 and 10, 1947, Mary Louise Perry (MS) visited Richardson Grove State Park, Humboldt County, California, in search of pallid bats reportedly inhabiting hollow redwood trees in the grove. A number of hollow trees were examined and two were found to have been inhabited by bats although no bats were observed at this time. In the base of one tree the guano indicated that the inhabitants were probably all *Myotis.* About 98 per cent of the droppings in the other appeared to be those of *Myotis* but the remainder were large, about the size of those of *Antrozous.* According to Mr. Earl P. Hanson, assistant district superintendent at Humboldt Redwood State Park, *Antrozous pallidus* and *Myotis californicus* were the only species of bats that had, up to that time, been identified from Richardson Grove. Bailey (1936, p. 390) records a colony found in a hollow yellow pine in Jackson County, Oregon. The same author (1931, pp. 379–380) mentions another instance in which pallid bats that were disturbed in a cave in the daytime were noted seeking refuge in a hollow tree in the Cloverdale Hills in southwestern New Mexico. Hall (1946, p. 163) records a small group of these bats found roosting in a hole in a cottonwood tree at Ash Meadows, Nevada. Davis (1944, p. 380) found a colony of pallid bats using a cavity in a dead cypress as a daytime retreat in Nuevo Leon, Mexico.

While cavities in trees occasionally provide natural daytime retreats, crevices in rocks are most frequently used for this purpose. Several such daytime retreats were observed in San Luis Obispo and Kern counties. One of these was found on May 10, 1947, beneath a partly loosened slab of rock on a perpendicular cliff of an isolated sandstone outcrop 2½ miles northwest of Carneros Spring, Kern County (fig. 5). The entrance to the crevice was 7 feet above the ground and measured 2 feet in length and 4 inches in width. The crevice extended upward between the slab and the cliff for about 3 feet. The bats were crowded into the upper part of the cavity. The cliff below the opening was stained with urine and excrement and the ground beneath was covered with guano. Disturbance caused the bats to leave and fly around to another side of the outcrop where they were thought to have taken refuge in another crevice about 75 feet above the ground. The distance between these two crevices was about 100 yards. The roost which the bats had left was found unoccupied on September 20, 1947, although numerous droppings in the vicinity indicated that a colony of pallid bats still inhabited this isolated outcrop.

On June 7, 1948, two more colonies were located beneath loose slabs

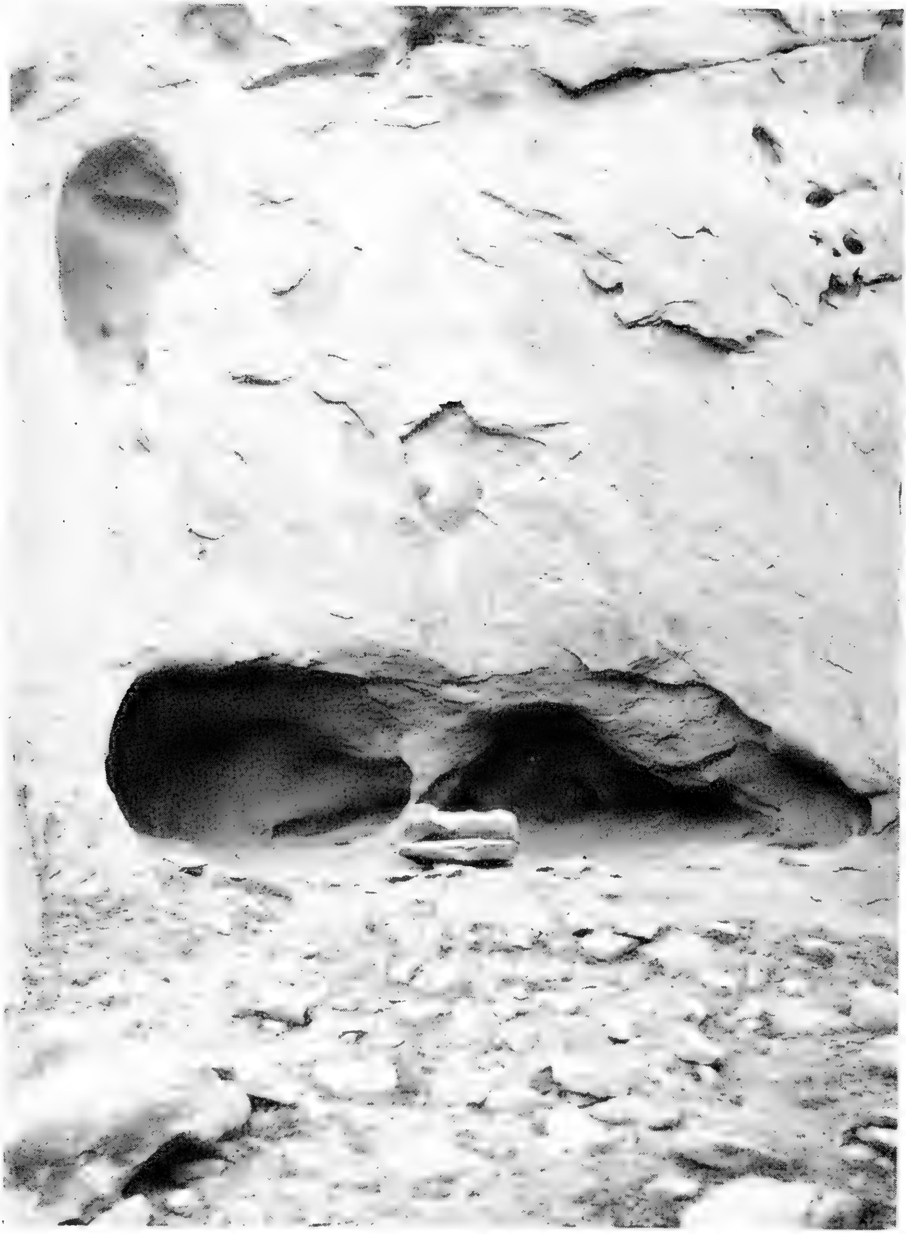


Figure 5. The crevice beneath the loose slab of sandstone in the center of the picture served as a day roost for a colony of pallid bats. Two and a half miles northwest of Carneros Spring, Kern County, California, September 20, 1947.

of sandstone at a rocky outcrop on the northwestern edge of the Carrizo Plain in San Luis Obispo County. One of the colonies occupied a daytime roost very similar to that just described. In this instance the entrance to the crevice was 12 feet above the ground. The colony was not disturbed on this date. On October 23, 1949, pallid bats were again found in this crevice and in a similar crevice 30 feet away. The entrance to the latter was only 6 feet above the ground. These two roosts were considered as belonging to the same colony. The second colony found on June 7, 1948, was about 200 yards from the one just described. The retreat occupied by these bats was also behind a partly loosened slab of sandstone on a cliff but it was situated about 20 feet above the ground and just above a narrow ledge of rock that was sufficiently wide for a person to walk on. The main entrance to the roost was a narrow, vertical opening, about 12 inches in length and 2 inches in width, at one side of the slab. The bottom of the opening was 12 inches above the ledge. Along the lower edge of the slab, where it contacted the ledge, there were two holes about a foot apart. Each hole measured approximately 3 inches in diameter. Accumulations of excrement that had rolled out through the holes were present on the ledge. All of the bats in this colony were crowded tightly together at the upper end of the crevice which was about 18 inches above the ledge. This was the only roost observed where the bats were unable to drop immediately after emerging. The ledge prevented them from so doing. Approximately two-thirds of the occupants were captured as they attempted to come out. The rest escaped. Those that escaped appeared to have no difficulty in taking flight immediately upon coming out of either the vertical slit or the two holes. The captured bats were released a short time later, after their sex had been recorded and the females palpated to determine pregnancy. The majority of those that either escaped or were released flew to a crevice in the roof of a shallow cave about 50 yards away. This alternative roost was known to have housed a colony of pallid bats the previous summer. When these roosts were visited on October 23, 1949, both were found uninhabited. It was difficult to tell whether the alternative roost in the roof of the cave had been used in the daytime during the summer of 1949. There were large accumulations of guano belonging to both pallid bats and Mexican free-tailed bats but both species were known to use the roof of this cave regularly as a night roost during the summer. The roost above the ledge showed no sign of having been occupied in 1949. When it was visited again on April 14, 1951, it was found to be occupied by a wood rat *(Neotoma lepida)*. This suggests the possibility that wood rats occasionally compete with these bats for home sites.

On June 8, 1948, two other colonies of pallid bats were found on the La Panza Ranch along San Juan Creek, San Luis Obispo County, about 9 miles west of Simmler. One was located in a crevice beneath a loose slab of rock on the face of a nearly vertical cliff (fig. 6). The entrance to the crevice was 10 feet above the ground and consisted of an opening 3 feet in length and about 4 inches in width. The crevice extended upward approximately 3 feet and the bats were in the uppermost part. When some of these bats were captured the following day the other members of the colony left. All those seen leaving flew down the canyon through which the creek flowed and were out of sight as soon as they rounded a bend several hundred feet away. One gained the impression that they were moving to an alternative roost known to them although this was not found by the observers. The roost deserted at this time was found occupied in the summer of 1949 and again in the spring of 1951. It was not examined in 1950.

The second colony found on June 8, 1948, on the La Panza Ranch was about half a mile farther up the canyon in a small cave. The cave, situated at the base of a sandstone cliff, was dome-shaped and about 10 feet in diameter. The distance from the floor of the cave to the highest point was also about 10 feet. On one side of the dome there was a funnel-shaped recess which led into a short, narrow crevice in which the bats were observed roosting. There were two openings into the cave from the outside. One of these was irregular in shape. It extended from the ground up to a height of 3½ feet and was about 2½ feet in width. Above this, about 5 feet from the ground, there was another opening 1 foot wide and 2 feet in height. The lower opening, judging from the presence of many droppings, was the one more frequently used by the bats when entering or leaving. In the center of the floor of the cave there was a broad, cone-shaped pile of excrement 3 to 4 feet in diameter and attaining a maximum depth of 12 inches. The presence of observers close to this cave during the night caused the colony to move to another roost by dawn the following morning. It was visited in the summer of 1949 and again in the spring of 1951 and found unoccupied in the daytime on each occasion although fresh accumulations of guano in each instance showed that the dome of the cave still served as a night roost.

There is a possibility that these bats might roost beneath rock slides or in talus slopes in certain localities although no such colonies have been located. Racey (1933, p. 18), however, records the discovery of a single bat of this species beneath a pile of stones in British Columbia.

Pallid bats frequently find suitable roosts in attics, between walls, between bridge timbers, and in other similar hiding places in man-made structures. One such colony that was periodically under obser-

Figure 6. The crevice on the sandstone cliff in the center of the picture housed a colony of pallid bats. La Panza Ranch, San Juan Creek, San Luis Obispo County, California, June 9, 1948.

vation during this study inhabited a barn (fig. 7) and a shed immediately adjacent to the barn on a ranch 4½ miles northeast of Shandon, San Luis Obispo County. Sometimes the entire colony was in one or the other of the buildings and sometimes it was divided, with bats in both buildings. In each structure the bats occupied small spaces at either end between the timbers that supported the roof. Since the crevices were small and could not hold many bats, the colony was divided into a number of groups. Disturbance never caused members of this colony to desert the buildings although they might fly from one building to the other or move to the opposite end of the roof of the same building.

Figure 7. Pallid bats inhabiting this barn, 4½ miles northeast of Shandon, San Luis Obispo County, California, were observed entering and leaving through the opening seen immediately below the peak of the roof. Photographed October 22, 1949.

On June 7, 1951, Sterling Bunnell examined a colony of pallid bats living in the attic of Encina Hall at Stanford University in Palo Alto. Some adult females and young were captured. The writer examined the attic of this building a few days later on June 13. The attic was found to be divided into a number of sections, each about 40 feet long and equally wide. Brick walls served as partitions between adjoining sections. Beams 2 inches by 12 inches rested on the brick partitions and supported the roof. No bats were found in the section where they had been roosting on June 7 although there were large accumulations of droppings at the bases of the brick partitions at each end. Two partitions away, however, about 40 pallid bats were found roosting in spaces between the top of one of the brick partitions and the roof. It seemed likely that these were the same bats that had been living in the other part of the attic on June 7.

Another colony discovered by Eben McMillan (*fide* letter of April 24, 1949) in western San Luis Obispo County, between Paso Robles and Cambria, was located in a space between the window panes and some boards that had been nailed across the windows of an old house.

There are numerous records in the literature of pallid bats using man-made structures, a few of which are cited here. Krutzsch (1946, p. 241) records bats of this species living in a barn, in the attic of a church, and in cracks between the beams of a bridge. Hall (1946, p. 163) describes a group of these bats found near Lahontan Dam, Nevada, that had "ensconced themselves in the crevices, ½ to 1 inch in width, between the 18-inch timbers on the underside of a bridge." Storer (1931, p. 244) records a summering colony of pallid bats found living in the walls of a residence in Berkeley, California. Bailey (1905, p. 214) mentions pallid bats roosting behind a signboard at Comstock, Texas.

At night pallid bats frequently alight, at what are generally referred to as night roosts, to rest or to consume food that has just been captured. These so-called night roosts are much more accessible to the bats than the crowded recesses that constitute daytime retreats. Bats living in barns or attics usually use the ridgepole of the roof for such purposes. In rocky areas the roofs of shallow caves frequently provide night roosts (fig. 8). Large accumulations of guano and parts of insects that have been discarded are present beneath such roosts (fig. 9). Early in April, 1949, the floor of one such roost in a small cave on the La Panza Ranch was scraped clean. When examined six months later on October 23 a new accumulation of guano was found that measured 4 feet in diameter and 7 inches in depth in the center.

The night roosts of all the colonies whose daytime retreats were known were usually within a few yards of these daytime retreats. In one instance the night roost of a colony was not located although no great effort was made to find it in the numerous rocky recesses nearby. Several night roosts regularly used by pallid bats were found although diligent search failed to reveal the whereabouts of the day roosts. In each instance, however, possible hiding places nearby were inaccessible to the observer.

The night roosts of these bats in buildings are frequently a source of considerable annoyance to the owners. Bats belonging to one colony under observation used, for this purpose, either the ridgepole of a barn or the ridgepole of an adjacent shed that served as a garage. As a re-

Figure 8. The roof of this shallow cavern near San Juan Creek on the La Panza Ranch, San Luis Obispo County, California, served as a night roost for pallid bats and Mexican free-tailed bats. Photographed June 8, 1948.

Figure 9. Accumulation of guano beneath the night roost shown in figure 8. Photographed October 23, 1949.

sult, the bat excrement fouled hay that was stored in the barn and made it necessary to hang a cloth covering over the car in the garage to keep it clean. Members of another colony were observed using the beams supporting the roof of an open porch of a ranch house for a night roost. The house was less than one year old when examined on the evening of April 13, 1951, and the two-by-four beams of the porch roof had been freshly creosoted. This apparently was no deterrent as 6 bats were seen hanging from a beam at one end of the porch and 3 from a beam at the opposite end at 9:55 P.M. Fresh droppings and insect remains were found on the concrete beneath each small group.

The fact that an electric light had been burning on the porch all evening did not seem to discourage the bats from coming here any more than did the creosote.

SEASONAL BEHAVIOR

Spring and summer: By late March or early April the period of dormancy appears to terminate in central California and summer colony formation occurs. Mrs. Grinnell (1918, p. 356) records March 27 as the earliest known date of observation of this species in spring in this state. In Texas, Bailey (1905, p. 214) indicates April 18 as the earliest seasonal date on which the species was noted.

In the spring of 1949 an examination of four sandstone crevices in eastern San Luis Obispo County, where summering colonies had been observed in 1947 and 1948, failed to reveal the presence of any pallid bats on April 1, 2, and 3. A very few fresh droppings beneath two of the colony sites indicated that one or at most a very few bats had recently been present. During the ensuing two weeks Mr. Eben McMillan periodically visited one of these colony sites and a barn in which pallid bats had been found every summer for some years. Bats were found in the barn on April 10 and in the sandstone crevice on April 14. In each instance they appeared to have arrived not more than a day or so previously. No effort was made to determine the number of individuals present on the first day bats were found in these colonies, but on April 15 it was estimated that about 30 individuals were present in the colony first occupied on April 10. Seventeen of these were captured, of which 15 were females and 2 were males. Five of the females were banded bats that had been captured by the writer at the same place on September 20, 1947, and kept in captivity in San Francisco until June 6, 1948, at which time they were released at the original site of capture. This represented a 25 per cent return since 15 other pallid bats, taken at the same place and on the same date, were also released here with bands on their forearms on June 6, 1948. It is probable that additional banded individuals were present in the colony on April 15, 1949, but they were not captured.

This same colony was visited on April 14, 1951. The owner of the ranch on which the barn that housed the bats was situated stated that the colony had made its appearance several weeks before. Difficulty in gaining access to the roof of the barn made it possible to capture only 5 females and 4 males, although many more bats were heard and known to be present. Two of the females and one of the males were banded bats. One female belonged to the group originally captured on September 20, 1947, and released on June 6, 1948, after being kept in San Francisco for some months. It was not one of those recaptured on April 15, 1949. The other female and the male had been banded at this colony on October 22, 1949, and released immediately. On March 20, 1953, Dr. and Mrs. Karl B. Koford visited this colony and found 4 females and 1 male present. An unusually mild winter and early spring may have accounted for the early seasonal appearance of bats at this summer colony in 1953.

A second roost, known to have been inhabited the previous three summers, was visited on April 14, 1951, and found to be occupied. The small quantity of fresh guano on the previous years' deposit beneath the roost indicated that the colony had not been established here more than a week or two. Although about 40 pallid bats were estimated to be present, only 11 were captured. Two were males and 9 were females. In addition, 7 Mexican free-tailed bats were taken (2 males, 5 females). All were weighed, examined for parasites, and then released.

So far as known pallid bats are gregarious during the spring and summer months. The number of adult individuals comprising a colony was found to vary from about 30 to approximately 100. There is considerable variation in the sex ratio in different colonies and, seemingly, even within the same colony at different times. Luther Little (Mailliard, MS) captured 19 adults from a fairly large colony inhabiting a deserted building in Lake County, California, on April 16, 1919. Eighteen were males and 1 was a female. Twenty-two adults captured at random from a colony composed of about 40 individuals inhabiting the attic of Encina Hall, Stanford University, California, on June 13, 1951, consisted of 15 males and 7 females with young. Five adult females, however, had been taken from this same colony by another person the week before. Of 15 adults captured in western Kern County on May 10, 1947, from a colony estimated to consist of about 100 individuals, 8 were males and 7 were females (either pregnant or with young attached). Three adult males and 4 females, pregnant or with newborn young, were secured from a colony of 60 bats in eastern San Luis Obispo County on June 9, 1948. Two days previously a random sample from another colony of similar size several miles away consisted of 7 adult males and 35 pregnant females. Thirty-seven pallid bats captured from another colony in this region on September 20, 1947, consisted of 8 males and 29 females. At this time the number of individuals in the colony was estimated to be somewhat in excess of 60. On June 6, 1948, 26 adults were captured at random at this same colony. Sixteen were males and 10 were pregnant females. As has been previously stated, on April 14, 1949, shortly after the formation of this colony in the spring, a random catch produced 2 adult males and 15 adult females. Another random catch on April 14, 1951, produced 4 adult males and 5 adult females, and on March 20, 1953, there were 1 adult male and 4 adult females in the colony.

Storer (1931, p. 244) records the capture of 8 adult or nearly adult males and 13 females, either pregnant or with young, from a colony of pallid bats living between the walls of a residence in Berkeley, California, on June 24, 1919. Hall (1946, p. 163), on the other hand, referring to this species in Nevada, states that "Pallid bats separate by sex in spring before the young are born. The females then are in colonies. About fifty females is the largest number observed in one colony." Dalquest (1947, p. 24) records a colony of pallid bats, consisting of about 60 males, found in the attic of an old winery near Angwin, Napa County, California, on July 8, 1945.

Figure 10. Mexican free-tailed bats are very frequently associated with pallid bats in the wild. When housed in the same laboratory cage members of the two species stayed together. Photographed at the California Academy of Sciences, December 12, 1952.

From the foregoing observations it can be seen that, in California at least, summering colonies may be composed of adults of both sexes and that either sex may predominate in numbers.

Although big brown bats *(Eptesicus fuscus)*, several species of *Myotis*, and lump-nosed bats *(Corynorhinus rafinesquei)* may occasionally be found in the same cave, building, or even attic with pallid bats in the daytime during the summer, they do not seem to share the same roost with members of the last species. Only the Mexican free-tailed bat *(Tadarida mexicana)* is commonly found in pallid bat roosts (fig. 10). Most of the pallid bat colonies examined were found to contain one or more of these small molossids. The greatest number observed with pallid bats in one colony was 17. Members of either or both sexes may be represented, including pregnant females in the late spring and summer. Individuals of this species were found to be equally common in colonies of big brown bats.

Krutzsch (1946, p. 241), discussing big brown bats in San Diego County, California, states that: "*Eptesicus, Tadarida*, and *Antrozous* have been found living successfully in the same building, a barn on the grounds of The Old People's Home, in the attic of the San Marco Church, and in various cracks between the "I" beams of the bridge at the juncture of Highways 79 and 80." Dalquest (1947) mentions finding *Corynorhinus rafinesquei, Myotis yumanensis, Myotis thysanodes*, and *Tadarida mexicana* inhabiting the same buildings as pallid bats during the daytime. Bailey (1936, p. 392) records a mixed colony of pallid bats and Mexican free-tailed bats found in Carson Valley, Nevada. Hall (1946, p. 165) records 2 pipistrelles *(Pipistrellus hesperus)* and 1 little brown bat *(Myotis californicus)* hanging in a mine tunnel in which 2 pallid bats were found hibernating near Yerington, Nevada, on December 27, 1939.

Fall: By the middle of September the adults have all completed the annual molt (many have done so by the middle of summer) and the young of the year have matured to the stage where they are indistinguishable, at least in the field, from adults. No evidence was obtained to indicate dissolution of the summer colonies this early. By the middle of October, however, the summer colonies tend to break up into smaller groups. At this time pallid bats may be found in situations where they do not occur in summer.

On October 22 and 23, 1949, some known summer colony sites in eastern San Luis Obispo County were examined. The first colony visited was in the barn, previously mentioned, where 20 banded individuals captured on September 20, 1947, had been released on June 6, 1948. Although over 60 bats were generally found here in summer there were only 12 on October 22. Six were males and 6 were females.

One of the females was a banded individual, one of the group captured on September 20, 1947.

Examination of a deserted cabin about one mile from this colony resulted in the discovery of a male and a female pallid bat hanging side by side behind a loose board in one of the rooms. Although this cabin had been investigated many times before in winter, spring, and summer, the only bats previously found here had been of the species *Myotis subulatus.* Later that evening the night roost of another colony of pallid bats was visited and 8 or 10 individuals were observed hanging there before the approach of intruders disturbed them.

The following day the site of another summer colony was visited. It contained only 7 bats, 5 of which were captured. Two of these were males and 3 were females. About 30 feet away another small group composed of 13 pallid bats was discovered. Only two of these were captured. They proved to be females. Examination of two other summer colony sites that day showed that one had recently been vacated while the other contained 5 pallid bats and 15 Mexican free-tailed bats. None of the former were captured.

Mr. Eben McMillan made some interesting observations on the appearance of pallid bats in the fall of 1948 and 1949 on the Pinole Ranch at the north end of the Carrizo Plain in eastern San Luis Obispo County. No pallid bats were seen about the ranch buildings in the spring or summer months of these two years. In 1948, however, between the latter part of October and the middle of November, pallid bats were found hanging each night from beams supporting the grain bins. Each morning during this period numerous droppings and fragments of insects, presumably discarded by the bats, were found on the ground beneath the beams. After the middle of November the bats were no longer seen. In 1949 pallid bats again appeared here during the second week in October. On October 23 the writer observed many fresh droppings as well as remains of Jerusalem crickets on some clean sacks that had been placed beneath this temporary night roost the evening before. During the next week or so Mr. McMillan examined the sacks each day and then cleaned them. After October 25 there was a gradual decrease in the number of droppings found daily until November 1. On this date there were only two droppings and none were found subsequently that year.

Winter: Very little information is available regarding the whereabouts of pallid bats between the middle of November and the end of March. They are not to be found in their summer retreats nor are they active at night, as far as could be determined. There is no evidence to indicate that members of this species migrate in the strict sense of the word although unquestionably there is a local shifting and probably a dispersal of summer populations. Such meager information as was acquired seems to indicate that single individuals or small groups of these bats seek remote retreats where they are not likely to be disturbed.

Referring to this species in Nevada, Hall (1946, p. 165) says: "The hibernating individuals consisted of two males found December 27, 1939, in a mine tunnel 9 miles east and 2 miles north of Yerington, 120 and 138 feet from the mouth of the tunnel. Each bat was in a crevice in the roof of the tunnel and had its ears erect and its eyes open. The bats were unable to fly and their movements were slow. The temperature inside the mine where the bats were was 60°F.; outside the mine it was between 40° and 50°F. (Alcorn, MS)." Alcorn (1944, pp. 309–310), referring to the same cave, mentions that pallid bats were noted here during three winters.

Mrs. Grinnell (1918, p. 356) records two females in the collection of Stanford University taken on January 1, 1895, at Carmel Mission, Monterey County, California. A female (no. 106583) in the collection of the Museum of Vertebrate Zoology, University of California, was taken at Woodside, Santa Clara County, on January 17, 1947. It weighed 22.3 grams.

On January 18, 1950, a male pallid bat was received that had been captured three days previously in Mill Valley, Marin County, California, by Thomas Leech. Although the animal had been in captivity for three days its weight upon receipt was 26.5 grams. A few days later, January 22, the writer visited the place where the bat had been found. It proved to be an old, deserted, one and one-half story cabin situated in a rather dense redwood forest on a northeast-facing slope. The bat had been found hanging on the outside of the building beneath an old piece of damp canvas where it undoubtedly was dark, cool, and damp all winter. Further search failed to uncover any additional pallid bats, although a female big brown bat *(Eptesicus fuscus)* and a female lump-nosed bat *(Corynorhinus rafinesquei)*, each dormant, were hanging within the cabin.

On December 1, 1940, E. Raymond Hall, Ned Stone, and Thane Riney found a male and two female pallid bats in a crevice in a limestone cliff 6 miles east of Walnut Creek, 1450 feet, Contra Costa County, California. The surrounding territory was covered with chaparral (Perry, MS).

Dr. Charles G. Sibley informed the writer that on January 28, 1940. he found 4 pallid bats in a semitorpid condition inside a hollow post holding up one end of an old lean-to on Bolinas Ridge, 1500 feet, Marin County, California. His attention was directed to the presence of the bats by faint noises, reminiscent of small mice, coming from within the post. Two of the bats were males, weighing 25.8 and 28.5 grams, and 2 were females, weighing 28.3 and 32.5 grams. They are now in the collection of the Museum of Vertebrate Zoology (nos. 90572–90575).

On March 13, 1950, Mr. Eben McMillan found a torpid female pallid bat hanging beneath a loose board in a deserted cabin about 5 miles northeast of Shandon, 1300 feet, San Luis Obispo County, California. This is the only possible winter record that was obtained from San Luis Obispo and Kern counties. Mr. McMillan and the writer had found a male and female of this species, in breeding condition, hanging beneath this same board on October 22, 1949. Careful search for wintering bats, on other occasions, in old buildings, mine tunnels, caves, and other possible retreats in parts of Monterey, San Luis Obispo, and Kern counties failed to reveal the presence of any pallid bats although bats of the following species were located: *Myotis thysanodes, Myotis volans, Myotis subulatus, Eptesicus fuscus,* and *Corynorhinus rafinesquei.* In this region, however, there are countless natural crevices in cliffs and rocky outcrops that are essentially inaccessible for human examination and which could serve as adequate hiding places for wintering bats.

Effect of enforced dormancy: Efforts were made to determine the effect of a simulated winter environment on captive individuals. On September 25, 1947, 6 females and 2 males, that had been captured a few days previously in eastern San Luis Obispo County, were placed in a small retaining cage in a refrigerated room where the temperature ranged from 40°F. to 50°F. To maintain fairly high humidity within the cage the screened front was covered with burlap which was dampened daily. A container with water was kept on the floor of the cage. No food was given the animals during the ensuing weeks.

The 2 males died, one after 14 days and the other at 40 days. Two of the females also died, one at 8 days and the other at 36 days. The death of some of these bats was suspected to have resulted from the toxic effect of aniline dyes placed on their bodies as a means of identification. The remaining 4 females were removed to a warm laboratory at the end of 43 days. During this period of enforced dormancy they had been weighed weekly. Occasional increases in weight were attributed to water that was believed to have been taken from time to time. The average loss in weight, per bat, at the end of 43 days amounted to 8.1 per cent or 0.184 per cent per day. The gradual loss in weight of 2 of these bats is shown in figure 11.

During the 28 days following the period of enforced dormancy these two bats were kept in a small cage in the laboratory and fed daily. Daily records were kept of their weights. As is shown in figure 11 there was a very rapid increase in weight during this time. The average increase, per bat, at the end of 27 days amounted to 60.8 per cent or 2.25

per cent per day. On the last day there was a slight decline in the weight of each bat.

At the end of this 28-day period these two bats were returned to the refrigerated room and kept there from December 5, 1947, until April 27, 1948, under the same conditions used in the first dormancy experiment. At the end of this period of 144 days the decline in body weight, per bat, averaged 27.6 per cent or 0.193 per cent per day (fig. 11).

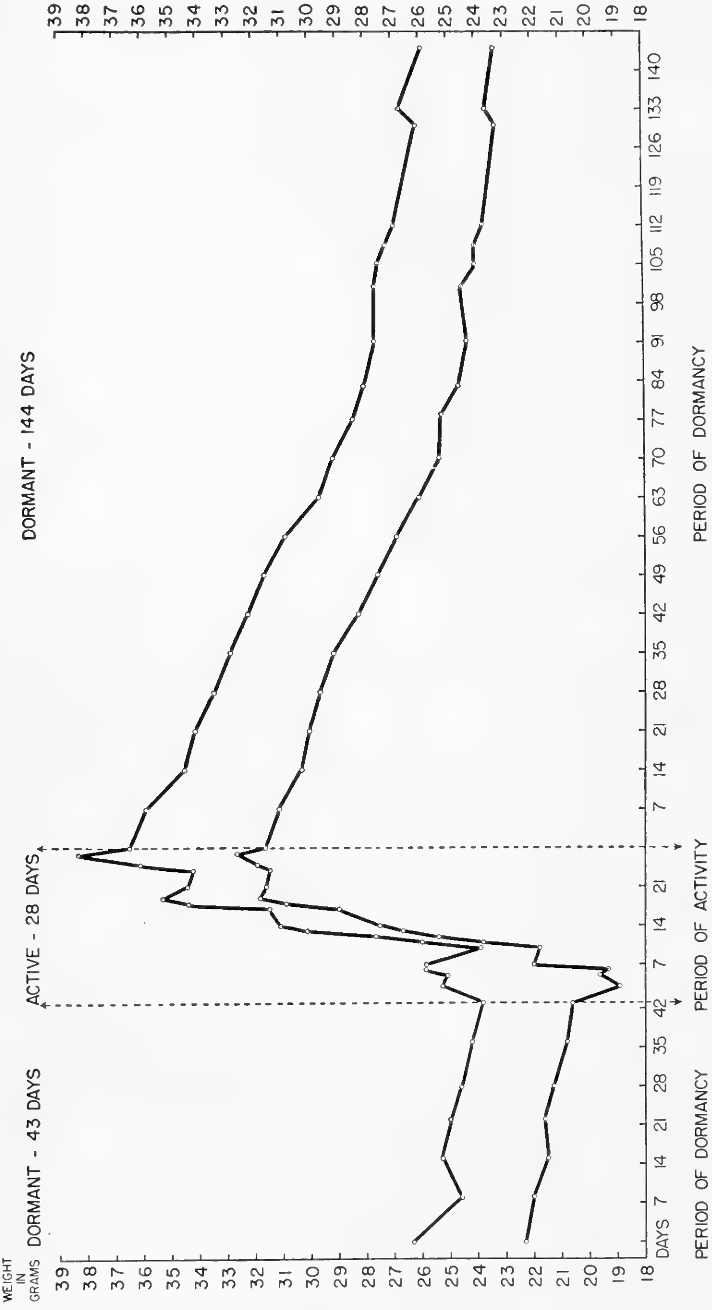
On November 15, 1950, 4 pallid bats (3 males, 1 female) that had been captured at Farmington, San Joaquin County, California, on October 27, 1950, were placed in a cage in a refrigerated room and kept there until March 14, 1951. They were provided with drinking water and the front of the cage was kept covered with damp burlap. During this period of 119 days the temperature of the room was kept at 38°F. to 40°F. The bats were weighed weekly. The average loss in weight, per bat, amounted to 24.96 per cent or 0.209 per cent per day (fig. 12).

In each of the three dormancy experiments mentioned the bats hung from the screened side of the cage. The water container was visited by one or more of the bats about every 3 to 5 days. This was demonstrated by placing a thin layer of fine dry sand on the bottom of the cage and examining it every day or so for tracks. When tracks were found leading to the water dish the sand was smoothed over again. Several investigators have previously suggested the possibility that hibernating bats are periodically aroused by thirst. This may have been true of these captive individuals since they periodically visited the water container and on several occasions a temporary increase in body weight was noted. Under natural conditions most hibernating bats that have been studied are not far from water, either in the form of accumulated droplets in the hibernacula or in streams and ponds nearby. Folk (1940, p. 312) observed little brown bats *(Myotis lucifugus)*, aroused from a torpid condition in winter in a cave in New York, lapping drops of moisture condensed on the wall. Furthermore, there is occasional shifting of individuals during the general period of dormancy which may be the result of movement to and from water. As is shown in figures 11 and 12 the greatest loss in weight occurred during either the first or second week of enforced dormancy.

The respiration rate in dormant individuals varied greatly and

---

Figure 11. Graph showing changes in body weights of 2 pallid bats kept without food at 40°F. to 50°F. for 43 days, then removed to a warm laboratory room and fed for 28 days, following which they were again kept at 40°F. to 50°F. without food for 144 days.


WEIGHT IN GRAMS
39
38
37
36
35
34
33
32
31
30
29
28
27
26
25
24
23
22
21
20
19
18
DORMANT - 43 DAYS
ACTIVE - 28 DAYS
DORMANT - 144 DAYS
DAYS
7
14
21
28
35
42
7
14
21
7
14
21
28
35
42
49
56
63
70
77
84
91
98
105
112
119
126
133
140
PERIOD OF DORMANCY
PERIOD OF ACTIVITY
PERIOD OF DORMANCY

was difficult to determine accurately. Bats cannot be said to become truly torpid since even the turning on of a light in the refrigerated room at times stimulated breathing. The noise involved in the opening of a door or the sound of footsteps had the same effect. Numerous respiratory counts made on the bats maintained in a refrigerated room showed a range of 0 to 52 per minute. The greatest period in which no obvious sign of breathing was observed was 4 minutes.

Dormant bats, when suddenly handled, reacted feebly at first. The mouth was generally opened wide and a weak buzzing sound produced. Following this, if the wings were free, one or both of them would be slowly extended and then held stiffly in an outspread position. No attempt, of course, was made to disturb dormant individuals any more than was necessary. When two females were placed in the sun in an outdoor flight cage after 144 days of confinement without food in a refrigerated room they were capable of sustained flight within 15 minutes.

Neither bats kept in the laboratory nor those in outdoor flight cages became dormant for any considerable period of time during the winter. They were, however, more sluggish and ate less at this season. Those in outdoor cages occasionally failed to take any food on cold or stormy nights.

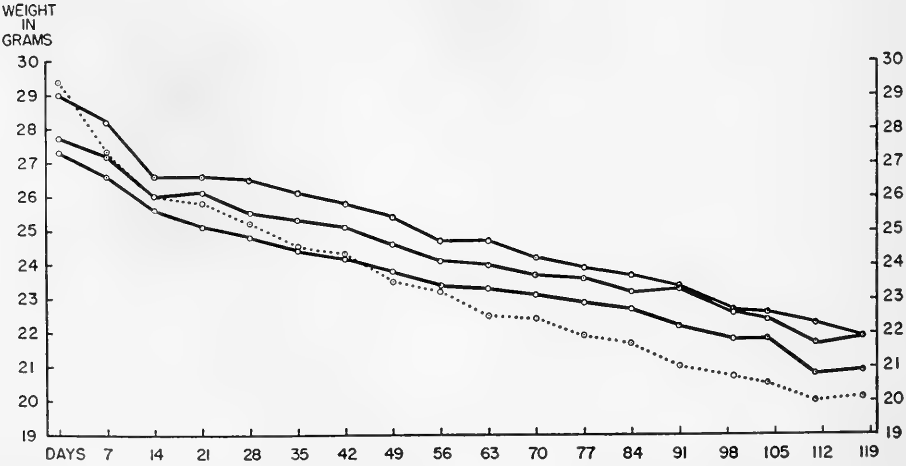


Figure 12. Graph showing gradual loss in body weights of 4 pallid bats kept at 38°F. to 40°F., without food, for 119 days. Solid lines indicate males, the dotted line a female.

Seasonal fluctuation in body weight: As is shown in figure 11, captive pallid bats are capable of increasing body weight rapidly after a period of dormancy. Data on bats from a single colony, presented in table II, indicate that this is also probably true of these bats in the wild. Males captured in April, 1951, several weeks after their appearance in the summer colony, weighed about the same as males taken in June. Males captured only a few days after their arrival in the summer colony in April, 1949, weighed considerably less. Females continued to increase in weight from the time of their arrival in spring until the young were born. Although no opportunity was afforded to secure weights of females from this particular colony immediately after the period of parturition, the average and extreme weights of 7 females, captured June 13, 1951, in Santa Clara County, California, that had young from about 3 to 6 weeks old, were 26.8 (25.1–29.3) grams. There appeared to be an increase in the weight of bats of both sexes again in the fall.

TABLE II

Average weights, in grams, of pallid bats from a single colony 4½ miles northeast of Shandon, San Luis Obispo County, California, in spring, summer, and autumn. Figures in parentheses represent numbers averaged.

Date	Males	Females	Reproductive Status
April 16, 1949	20.6 (2)	24.3 (15)	Females had recently ovulated
April 14, 1951[2]	25.1 (3)	31.7 (2)	Females with well developed embryos
June 6, 1948	25.2 (16)	34.7 (10)	Females in late pregnancy
October 22, 1949	29.4 (7)	28.3 (7)	Copulation occurring

DAILY BEHAVIOR

Voice: A number of different kinds of audible sounds are produced by pallid bats. Each of these seems to be associated with a particular type of behavior.

The "intimidation" note is a loud, strong, dry, insect-like buzz that is uttered when a bat is frightened, angered, or very annoyed. The

---

[2] The fact that bats secured from this colony weighed more in the middle of April, 1951, than those secured about the same date in April, 1949, is attributed to their earlier seasonal appearance in 1951.

mouth is half-opened and the teeth bared at such times. From 1 to 7 successive buzzes may be given with equal time intervals between. The rate of utterance is about 3 to 5 per second. The individual buzzy notes are all of approximately the same pitch, quality, intensity, and duration. Any disturbance of a roosting colony during the day immediately resulted in one or more of the bats uttering this sound. Captive bats uttered the intimidation buzz when disturbed by persons attempting to handle them, when disturbed by other bats in the same cage, or when suddenly startled. This note was frequently uttered during the day by a female that was attempting to discourage her nearly grown young from nursing.

The ''squabble'' consists of a series of high-pitched, dry, rasping, thin, double notes of duration varying up to one second. In certain respects it resembles the squeaky note of the Anna hummingbird. This sound is produced with the mouth open and the teeth bared. Squabbling appeared to be a sign of irritability and anger and was uttered by individuals that were being crowded too much or slightly hurt by other bats. It was frequently heard during the day, especially when it was warm and the bats were restless. On several occasions the squabbling of pallid bats led to the discovery of colonies in the field.

The "directive" call usually consists of 1 to 5 rapidly repeated notes with equal time intervals between. The notes are single, clear, resonant in quality, and of a high pitch. They might be phonetically described as ''sit'' or ''sit-sit-sit,'' depending on the number of notes uttered, and remind one of the sound made by a power line with a short circuit. This call is usually given as soon as a bat takes flight in the evening on emerging from a daytime roost. It was occasionally uttered by captive individuals when they were released for exercise in the laboratory. Captive bats were also heard to utter these notes sometimes while crawling about the laboratory or even when hanging in the room. This call is frequently heard at night in areas where pallid bats are abundant. On one occasion, in the midafternoon, 42 bats that had just been captured and examined were released one at a time close to their roost. The first 5 flew about for a few moments then entered a crevice in a rock. They uttered the directive notes after they disappeared from sight. These notes were answered by other bats, that were then released, and seemed to serve as a means of directing the latter to the same crevice. On another occasion, in the laboratory, it was noted that the utterance of directive notes by a bat 3½ months old caused 3 adults to fly to the young, hang next to it, and nuzzle it.

The directive note of the young pallid bats may be described as a "chirp." This is a high-pitched, bird-like note that the young are capable of uttering from the very moment of birth until they are old enough to produce the adult type of directive note previously described. In captivity chirps were uttered as soon as a young bat became detached from its mother and were repeated monotonously until the parent rejoined the young. The frequency of utterance of these notes during periods of detachment increased from 2 or 3 per second during the first day of postnatal life to 5 per second by the tenth day. By the time young bats were about 12 days old this chirp was replaced by a directive call similar to that given by adults. In one instance this change in voice occurred at the age of 7 days. The chirp seemed to serve as a means of acquainting the female with the location of her young. When a female was separated from her young and released in another part of the room, or a young bat was taken from its mother and placed in another part of the room, the parent seemed to depend upon this sound to locate her offspring.

A sound which may be described as "chittering" was heard on some occasions. Although its significance is not clearly known, it was suspected of being a note of contentment. Each of these notes was of a high pitch, although the intensity varied slightly, of about one-half second duration, and repeated 3 or 4 times with half-second intervals between notes. On one occasion these chittering notes were heard coming from a cage in which an adult female and her 6-weeks old young were hanging side by side. Laboratory-reared bats that were very tame were occasionally heard uttering these notes during the daytime until they were 18 months old.

A "plaintive" note, presumably associated with pain, was uttered by females in labor. Such notes were high-pitched but not as high as the directive notes. They were loud, gutteral, harsh, double notes repeated 3 or 4 times, each note having a duration of about 2 seconds. They were uttered with the mouth open, the lips drawn back, and the eyes partly closed. They evoked no response from other bats in the same cage.

On occasion as bats groom themselves they produce a non-vocal, explosive, nasal sound. This apparently is the result of a sudden release of air through the nasal passages and may serve as a means of dislodging loose hairs that adhere to the nose.

When bats were flying about in a laboratory room they could be heard making faint clicks as they passed close by the observer. These same clicks were often produced by tame bats held in the hand at times when they were restless and about to take flight. The writer did not have an opportunity to study ultrasonic sounds produced by these bats but was kindly supplied with some information by Dr. F. Alton Everest of the Moody Institute of Science in Los Angeles. Through the cooperation of Mr. Eben McMillan 3 adult female and 3 nursing young pallid bats were secured by Dr. Everest at one of the colonies under observation by the writer on the Carrizo Plain. By means of an ultrasonic amplifier it was found that during flight these bats emit a very narrow beam of sound from the open mouth. The signal strength of this sound was found to fall very rapidly when the mouth was not aimed directly at the microphone. The same change in rate of click was observed as that described by Galambos and Griffin (1942). Pallid bats appeared to have an ultrasonic energy peak of about 40 kilocycles per second.

Locomotion: Pallid bats are capable of crawling quite well. When moving forward on a horizontal surface the weight of the body is borne on the wrists and feet. The knees are bent and directed upward and the tail is partly curled under. The fore part of the body is elevated more than the hind part. This position differs noticeably from that assumed by the Mexican free-tailed bat. Members of the latter species keep the body parallel to the surface on which they are crawling.

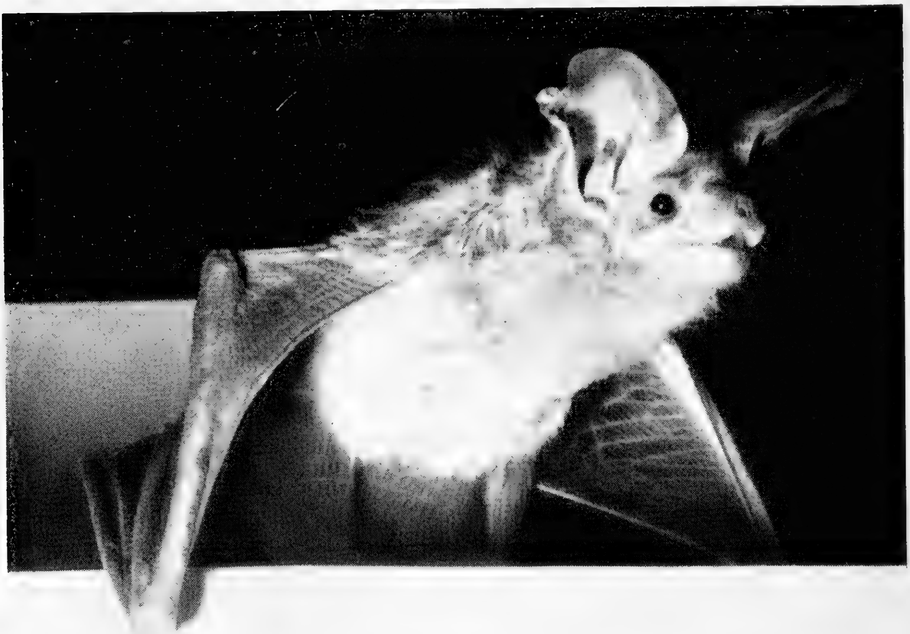


Figure 13. Pallid bat photographed at the moment it was taking flight from the edge of a table. Photographed at the California Academy of Sciences, October 26, 1952.

Figure 14. Shortly after the beginning of the downstroke. Photographed by Bob Lackenbach, September 1, 1949.

Figure 15. Position of wings in downstroke slightly later than shown in figure 14. Photographed at California Academy of Sciences, June 26, 1952.

Figure 16. Midway in the downstroke. Photographed at the California Academy of Sciences, December 10, 1952.

Figure 17. Near the end of the downstroke. Photographed by Bob Lackenbach, September 1, 1949.

Figure 18. At the end of the downstroke. Photographed at the California Academy of Sciences, November 20, 1952.

Pallid bats can climb readily, relying on the sharp claws of the hind toes and thumbs to hold on to vertical surfaces. If undisturbed when climbing they usually face the direction in which they are going. If they are bothered or frightened, however, they will frequently reverse their position and back up. No doubt this enables them to take flight more rapidly than would be possible if the head were facing upward. Likewise it generally makes it possible to direct intimidation notes and gestures more effectively toward the source of annoyance.

In flight, individuals of this species appear to be somewhat slower and less agile than many smaller bats. This impression results partly from the large size of the pallid bats. Their wing beats are slower and they require more room in which to turn. There is no question but that they lack the ability to maneuver in a limited space as effectively as smaller kinds of bats. It is questionable, however, whether they are actually slower flyers than most other vespertilionids. The Mexican free-tailed bat, on the other hand, which is a molossid with proportionately long, narrow wings, can outdistance the pallid bat very easily. Since these two species are frequently associated with one another, this was observed many times in the field as well as in the laboratory.

Field studies on flight under natural conditions were of little value as pallid bats emerge from their daytime roosts rather late in the eve-

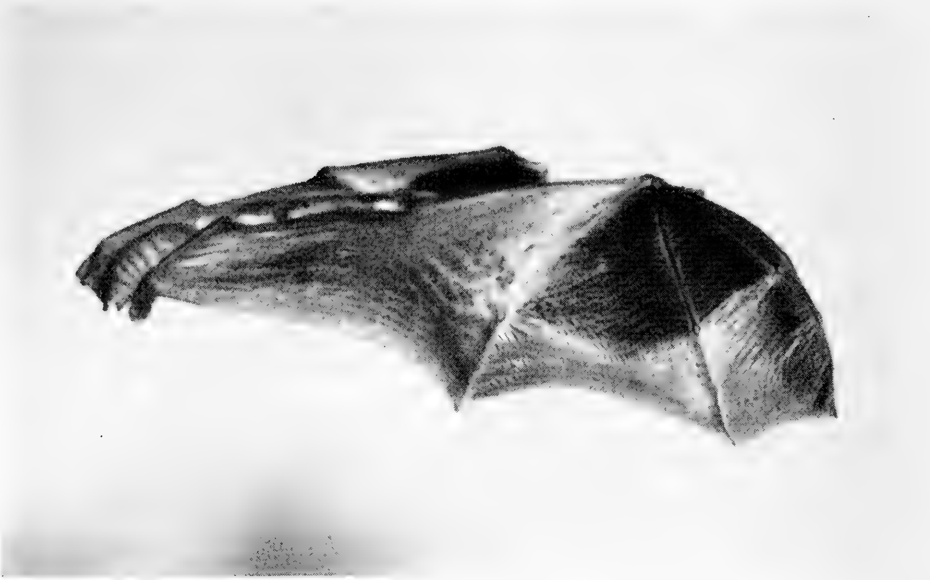


Figure 19. Midway in the upstroke as viewed from the side. Photographed at the California Academy of Sciences, November 20, 1952.

Figure 20. Midway in the upstroke as seen from below. Photographed at the California Academy of Sciences, November 20, 1952.

Figure 21. Near the end of the upstroke. Photographed at the California Academy of Sciences, April 29, 1953.

ning when the light intensity is very low. Studies, however, were made on the flight of captive bats in laboratory rooms. Direct observations were supplemented by slow motion films (64 frames per second) and stills made with a Speed Graphic and an Exacta VX using a Dormitzer Synctron electronic flash with a speed of about one five-thousandth of a second.

Before discussing the mechanics of flight it might be well to compare briefly a vespertilionid bat with a bird as regards the structures used in this form of locomotion. The chiropatagium may be considered as analogous to the outer half of a bird's wing. From the functional standpoint it serves the same purpose and acts as a propeller to effect forward progress. The plagiopatagium is analogous to the inner half of a bird's wing and like the latter serves to supply much of the necessary lift. The movement of the plagiopatagium is considerably less than that of the chiropatagium in flight. The anterior part of the bat's wing, like the anterior part of a bird's wing, possesses the greatest rigidity and it is here that the drive or pressure is exerted on the downstroke. The uropatagium is analogous to the tail feathers of the bird and may perform many of the same functions.

On extending the wing of a bat it will be seen that the tension of the membranes is sufficient to cause the fourth and fifth digits to flex slightly so that the ventral surface of the wing is concave and the dorsal surface convex. The greatest bend occurs between the fifth metacarpal and the first phalanx of the fifth digit. The downward bend of the fourth finger is less pronounced. As will be seen in figure 16 the position of the hind leg and the pressure exerted by the air beneath the plagiopatagium serve to maintain this camber in flight.

Figures 13 to 21 illustrate the action of the bat's wing. The motion is essentially the same as that of the wing of a bird in forward flight (Aymar, 1935, pp. 136–137; Storer, 1948, pp. 31–32). The downstroke is downward and forward while the upstroke is upward and backward. This has already been noted by Griffin (1946) whose studies on flight were based upon high-speed photography developed by Professor Harold E. Edgerton at the Massachusetts Institute of Technology.

In one respect the upstroke may be considered less efficient in the bat's wing than in the bird's wing. In the bird the flight feathers of the wing can separate during this action to allow air to pass between them, thus minimizing resistance. No action comparable to this is possible in the bat. However, in the bat, as in the bird, resistance is minimized by the generally convex shape of the upper surface of the wing as well as by a partial folding of the wing during the upstroke. Slow motion pictures also show that the wing action is much more rapid on the upstroke than on the downstroke. Furthermore, on the downstroke the uropatagium is depressed considerably as a result of the legs being pushed forward and the tail curled ventrally (fig. 18). This tends to increase the lift in a species such as the pallid bat which has a large uropatagial membrane and thus partly compensates for the loss occurring with the succeeding upstroke. The uropatagium does not straighten out until the wings are raised.

The uropatagium not only aids in increasing lift during sustained flight but serves as a brake when a bat is slowing down to alight or to avoid an obstacle suddenly placed in its way. Under these circumstances the legs are separated more widely than in regular flight and thrust far forward, thus depressing the uropatagium. At such times the angle of the body and wings is increased so as to approach the stalling point.

While in flight the thumb is always extended, essentially at right

Figure 22. A close view of the head of a pallid bat in flight showing the position of the pinna, tragus, and mouth. Photographed at the California Academy of Sciences, November 20, 1952.

angles to the anterior edge of the wing. The mouth is opened slightly and the upper and lower lips are decidedly drawn apart anteriorly (fig. 22). This is believed to be associated with the utterance of ultrasonic sounds.

In the laboratory, pallid bats were occasionally seen to hover momentarily when flying close to the floor. At such times their forward progress was essentially stopped. Such hovering action was thought to be associated with the habit these bats have of capturing food on the ground. Occasionally pallid bats were observed to glide for short distances with the wings fully extended and up and down motion suspended or so slight as to be hardly discernible.

The number of wing beats per second was found to be subject to considerable variation, depending on the type of flight. Griffin (1946, p. 119) states that "Bats make about 15 strokes of the wing per second. . . ." This may be true of the vespertilionid bats of eastern United States that he studied. The pallid bat, which is considerably larger than any of the cave-dwelling species of eastern North America, was found to make 10 to 11 strokes per second in ordinary straight flight. The rate of wing beat was found to increase under certain circumstances, as for example in executing a turn. On such occasions as many as 13½ strokes per second were recorded, while in a glide the number of strokes per second was reduced to zero for a brief period.

Pallid bats usually alight head up on vertical surfaces, catching on to the landing surface by means of the claws on their thumbs and hind feet. If the hind claws have found satisfactory crevices to cling to, the thumb holds are immediately released, as is also that of one hind foot. This causes the body to swing down to an inverted position at which time the claws of the thumbs and the released hind foot again grasp the landing surface. This method of alighting differs from that described by Dalquest (1947, p. 25), for *Corynorhinus rafinesquei,* a smaller and more agile species. It also differs decidedly from the way the phyllostomatid bat, *Macrotus californicus,* alights (Hatfield, 1937).

Odor: Pallid bats produce a very characteristic, skunk-like odor. On occasion one could detect this odor as much as 15 feet from an entrance to a roosting crevice. Disturbance of the bats results in a marked increase in the intensity of the odor. The odor is produced by the secretion of the glands on either side of the muzzle. On the surface of each gland are a number of pore-like depressions. A bristle is located in the center of each depression and each bristle is surrounded by about five smaller hairs (fig. 2). When a bat is disturbed, numerous tiny droplets of secretion are exuded within a few seconds and the odor becomes very strong. When the glands of a freshly killed bat are cut the odor becomes intense. It has been suggested that oil secreted by the nose glands of some bats is used to rub on the flight membranes to protect them from climatic conditions (Abdulali, 1949, p. 423). In the pallid bat, however, it seems more likely that the secretion may serve as a defense mechanism. It is true that members of this species frequently nuzzle their wing membranes but it is also true that the muzzle glands seem actively to secrete an odorous exudate only when the bats are alarmed. Perhaps this odor tends to repel certain other kinds of animals.

Diurnal behavior: Since the body temperature of many kinds of bats, including the species under discussion, has been found to be close to that of the environment when the animals are at rest during the day (fig. 23), it is not surprising that the behavior of these animals differs on cold days from that on warm days. On cool days, or early in the morning before it had warmed up, members of pallid bat colonies were found to be silent and essentially motionless until disturbed. If an individual was prodded at such times it would open its mouth and utter the intimidation buzz. Movement was slow at first and it was only after several minutes of continued disturbance that the bats would scramble around actively or be able to fly. On approaching a colony on a warm day one could frequently hear bats squabbling when 100 feet

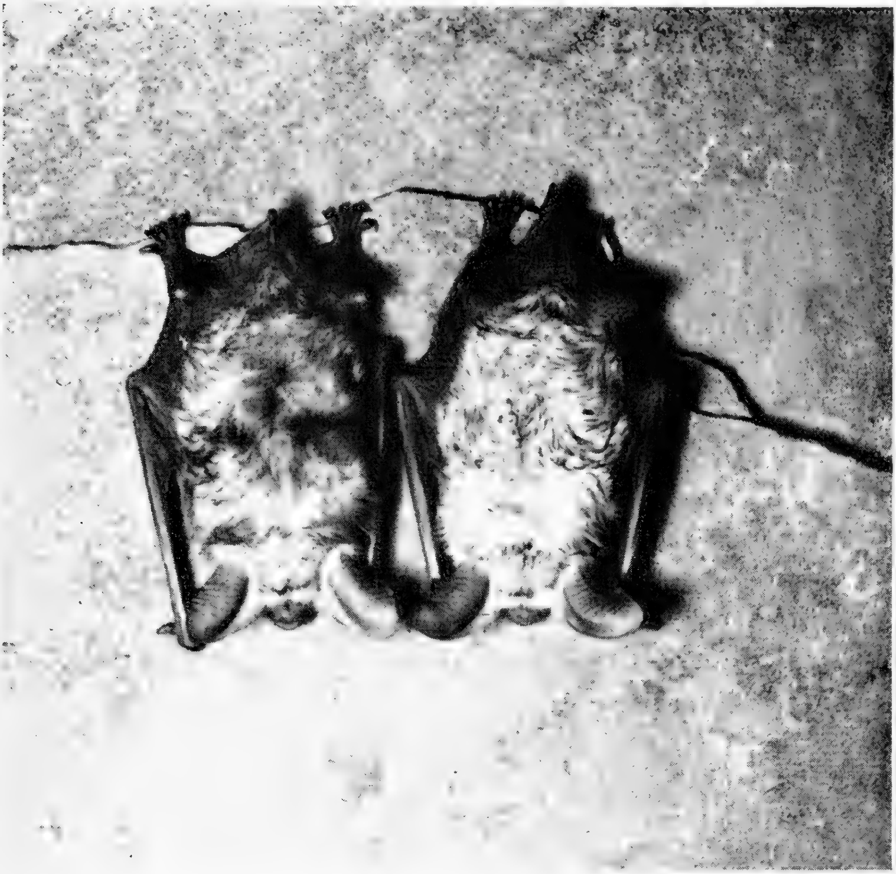


Figure 23. Typical posture assumed by captive pallid bats when sleeping during the day. Photographed at the California Academy of Sciences, December 12, 1952.

away. Any attempt to reach into a crevice resulted in numerous intimidation and squabble notes as the bats actively backed to the innermost part of the roost. They were very alert at such times, keeping their heads raised and often their mouths open. The latter act was interpreted as an intimidation gesture. If further disturbed, various individuals would try to move rapidly to the roost entrance and take flight. Likewise, in the laboratory cages much more activity and quarreling were evident when it was warm than when it was cool.

Newly captured bats usually bit viciously when grabbed. Anger at other bats was often expressed by biting if the intimidation buzz failed to discourage the annoyer. This was often preceded or accompanied by the squabble note. The majority of the bats that were kept in captivity for several months and handled regularly became accustomed to such treatment and ceased calling and biting when handled. However, they would usually open the mouth widely, bare the teeth, and occasionally move the jaws in a chewing sort of motion. Certain individuals never became tame while others became very tame. Some of the young born and reared in captivity would come of their own accord to the person that regularly cared for them and seemed to prefer being held in a hand to hanging in a cage. Bats that were wild or were being held in hand against their will would usually resort finally to spasmodic jerking of the body if all other means failed to give them freedom. Such behavior was frequently exhibited when body measurements or vaginal smears were being taken or when pelage examinations were being made. Such jerking ceased immediately when the animal was released.

During the day, captive bats were frequently observed nuzzling their fur and combing it with the hind claws. Whether or not the tongue was used in this cleaning process could not be determined. The flight membranes were also nuzzled and considerable time was devoted to scratching ectoparasites.

Captive pallid bats, both in laboratory and out-of-door cages, usually slept together in compact groups. Only occasionally would individuals stay apart from others in the cage and generally such behavior was the result of illness or injury. Not only did they customarily stay together but, after living in a cage a short while, developed the habit of roosting each day in the same place. When returned to a large flight cage after having been kept elsewhere for several weeks they would fly directly to the place where they had previously roosted. On several occasions roosts, consisting either of bricks or boards, were moved a few feet to determine the reaction of the bats upon being returned to a cage after an absence of two weeks. In each instance they flew to the original site of the roost and appeared bewildered. After a few moments of investigating, the new site of the roost was found. It was difficult to determine whether sight, odor, echo location, or all were involved in determining the position of the roosts.

On several occasions bats which had been captured in a barn in San Luis Obispo County were kept in San Francisco for as long as 13 months and then liberated at the original site of capture. Almost all of the bats, immediately upon being released outside of the barn in the daytime, flew directly to a small opening beneath the peak of the roof, that was regularly used by members of the colony as an exit and entrance to the attic of the barn where the roost was located.

Nocturnal behavior: Pallid bats do not emerge from their daytime roosts until fairly late in the evening. Observations made on June 8, 1948, on a colony in eastern San Luis Obispo County, showed that the first bats emerged 47 minutes after sunset at which time the illumination was less than 0.1 foot candles. By way of comparison, the first western pipistrelles were observed 2 minutes after sunset at which time the illumination was very high, and the first Mexican free-tailed bats emerged 17 minutes after sunset when the illumination was 3.0 foot candles. In the early morning of June 9, 1948, the last pallid bat was seen in flight 51 minutes before sunrise when the illumination was less than 0.1 foot candles. There is some evidence that in the fall of the year pallid bats, as well as several other species of bats observed, emerge earlier, relative to sunset, than in summer. On September 20, 1947, the first pallid bats were seen 19 minutes after sunset when the illumination was 0.15 foot candles. On that same evening western pipistrelle bats were seen 6 minutes before sunset and on the following evening Mexican free-tailed bats were seen emerging from daytime roosts 5 minutes before sunset. On this latter date, however, an overcast sky greatly reduced the amount of illumination. The earlier appearance of bats, in relation to sunset, in the autumn in the semiarid region where these observations were made may have been due to the scarcity of insect food at this season. Insects are less numerous in late September than in the middle of summer and less active after dark because of the cold. Certain other essentially crepuscular species of mammals, such as rabbits (Orr, 1940) are known to begin feeding activities much earlier in relation to sunset in winter when food is scarce than in summer when there is an abundance of palatable vegetation. Among diurnal birds Hinde (1952, p. 189) has shown that the great tit *(Parus major)* and the great spotted woodpecker *(Dendrocopos major)* roost later, relative to sunset, and emerge earlier, relative to sunrise, in midwinter than in autumn or spring.

Griffin and Welsh (1937) have shown that several species of insectivorous bats studied possess a definite activity rhythm, such as occurs in many other kinds of animals, and suggest (p. 342) that "Perhaps when the environment is constant, it is this internal mechanism that stimulates the animal at 24-hour intervals." No doubt this accounts for the rather uniform time of appearance of bats of the same species in the same region on a given date although seasonal changes in environmental conditions relating to food, temperature, and relative length of day and night undoubtedly affect the daily activity of bats in temperate regions.

On June 8, 1948, Mr. Eben McMillan, Mr. Ian McMillan, the writer, and his wife camped near a pallid bat colony along San Juan Creek in

San Luis Obispo County. From sunset that evening until after daybreak the following morning the entrances to the daytime roost and an adjacent night roost were kept under observation constantly by one or more members of the party. This was the second colony found on June 8, 1948, and has already been described on p. 181. At 7:30 p.m. a number of Mexican free-tailed bats were seen flying in and out of the cave in which the roost was located. The first pallid bat emerged at 8:00 p.m. During the next 15 minutes 4 more pallid bats emerged and during the next 5 minutes between 15 and 20 individuals made their exits. In each instance the lower opening of the cave was used. Each bat appeared to void urine a moment or so after emerging. On six occasions urine fell on a 10 by 12-foot tarpaulin located about 10 yards from the entrance to the cave and directly beneath the line of flight taken by the bats. After emerging from the cave each bat flew directly to the west about 50 yards where the ground level dropped abruptly about 20 feet to the creek. The bats upon reaching this point also dropped so that they were out of the observer's line of vision. It was suspected that the bats went directly to the creek to secure water but this was not determined. By 8:30 p.m., at which time it was nearly dark, some pallid bats were observed entering the night roost, which consisted of a shallow cavern in a cliff a few yards to the south of the daytime roost. During the remainder of the night bats were noted entering or leaving the night roost periodically. Sometimes quite a few individuals seemed to come at one time, sometimes they arrived singly in fairly rapid succession, and occasionally none would be noted for some minutes. Individuals approaching the night roost regularly uttered the directive call. Pallid bats were seen to enter the cave in which the daytime roost was located on only a very few occasions. At 11:00 p.m. 2 bats were found hanging from the roof of a small cavern about 30 feet north of the daytime retreat. At 12:30 a.m. about 8 or 10 pallid bats entered the main night roost and remained there until an observer approached with a flashlight at 1:10 a.m. All but two flew out. These remaining two were hanging from the roof of the cavern.

Between 1:57 a.m. and 3:00 a.m. an observer was stationed at the entrance to this night roost. A flashlight was occasionally used and there is little doubt that the presence of the observer disturbed the bats. However, a record was kept of the time and number of bats, whenever it was possible to determine the latter, that entered, as follows: 1:57 a.m., 1; 1:59 a.m., group; 2:01 a.m., 1; 2:02 a.m., 2; 2:04 a.m., 3; 2:07 a.m., 1; 2:09 a.m., group; 2:11 a.m., 3; 2:12 a.m., 1; 2:13 a.m., 2; 2:18 a.m., 2; 2:23 a.m., 2; 2:24 a.m., 1; 2:28 a.m., 12; 2:29 a.m., 2; 2:31 a.m., large group; observer left for 10 minutes to examine daytime roost and other night roost; 2:43 a.m., 1; 2:45 a.m., 1;

2:46 A.M., 1; 2:50 A.M., 1; 2:52 A.M., 2; 2:53 A.M., 1; 3:00 A.M., 1. It began to get light at 3:00 A.M. and from then on the number of bats seen decreased. The last pallid bat was seen flying near the entrance at 3:53 A.M. at which time it was fairly light. Investigation of the daytime roost at sunrise showed that it was deserted. Apparently the proximity of human beings during the night so disturbed the bats that they moved to an alternative roost, although the latter was not found by the observers.

The behavior pattern of the bats at this night roost conformed in general to that observed at other night roosts. Individuals came both singly and in groups. Frequently they would enter and seem to flutter momentarily against or hover near the wall of the cavern and then fly out. Occasionally individuals would alight. The time that they remained hanging varied from a few seconds to 40 minutes. It is probable that they often remain in a night roost for a considerably greater period of time than 40 minutes if undisturbed. Two other night roosts in natural caves were observed at night in addition to the roost observed on the night of June 8 and early morning of June 9. In most instances the bats observed hanging in these roosts were suspended by their feet from the center of the ceiling rather than hanging on the walls of the caves. As noted previously, however, this was not always true of bats using man-made structures for night roosts. Every pallid bat observed in a night roost was seen to be very alert and ready to take flight if alarmed. Nevertheless, by approaching slowly with a flashlight it was often possible to come within several feet of some individuals.

Reproduction

In captive males enlargement of the gonads became noticeable toward the latter part of August. This was accompanied by a marked increase in the size of the cremaster sack which had been hardly apparent during May, June, and July. No pallid bats were examined in the field in August. Enlargement of the testes was evident in both captive males and those examined in the field in September. By the middle of October, however, there was a marked decrease in the size of the testes of both captive and wild individuals. Weekly examinations of four caged males from the middle of October, 1947, to the end of April, 1948, showed a steady decrease in the size of the cremaster sack. At the end of this time it presented the appearance of two darkly pigmented lines.

As has been noted by others who have studied the reproductive cycle of vespertilionid bats in the northern hemisphere, this decrease in the size of the cremaster sack in the fall is associated with a decrease in the size of the testes rather than the epididymes. As long ago as 1879 Fries described the prolonged retention of sperm in the epididymis of certain European bats of the families Vespertilionidae and Rhinolophidae and also noted that the accessory male reproductive glands were functional from fall until spring. Similar observations were made by Rollinat and Trouessart (1896). The first detailed histological studies of the male reproductive tract in the Microchiroptera were made by Courrier (1927) on *Pipistrellus pipistrellus.* Courrier not only confirmed the conclusions of earlier workers but also found that spermatogenesis occurs during the summer months. Miller (1939), working on *Myotis lucifugus* and *Myotis grisescens* in this country, found a similar seasonal sequence in the reproductive cycles of males of these species as have Pearson, Koford, and Pearson (1952) in *Corynorhinus rafinesquei.*

Although the gonads of male pallid bats have attained maximum size by late August and September, no evidence was obtained to indicate that copulation occurs before the latter part of October, by which time a definite decrease in size of the gonads has occurred. Vaginal smears from 29 females taken from a colony containing members of both sexes, in eastern San Luis Obispo County, on September 20, 1947, failed to reveal the presence of any sperm. Since no uterine examinations were made of these bats this cannot be considered as conclusive evidence that no copulation had occurred. However, the absence of spermatozoa in smears from such a large number of females makes it seem unlikely that many, if any, had been inseminated. On October 22, 1949, vaginal smears were taken from 7 females captured in the same region. Spermatozoa were found present in 2 of the females.

The spermatozoon of this species possesses a rather elongate, oval-shaped head which is truncate posteriorly. The body or connecting piece is of but slightly lesser diameter than the head. Its length is nearly half of the total length of the spermatozoon. Posteriorly it tapers to its junction with the tail piece. The total length of an average spermatozoon, measured with an ocular micrometer, was 36μ.

A number of observations were made on the breeding activities of pallid bats in captivity. On September 25, 1947, 3 males and 3 females that had been captured 5 days previously were placed together in an indoor laboratory flight cage where the temperature ranged from 50°F. to 65°F. These bats, as well as others that were later placed in this cage, were banded so that the activities of each individual could be followed. A few minutes were devoted to observation each morning and again in the afternoon when the bats were fed. Two of the males failed to show any signs of sexual activity during the succeeding six months. These may have been young of the year although this could not be determined on the basis of external characters. Pearson, Koford, and Pearson (1952) have shown that it is improbable that the males of *Corynorhinus rafinesqui* copulate the first year. The third male was noted copulating with the same female on November 3, 18, 20, and 28. He was found copulating with the second female on November 9, and a vaginal smear taken from the third female on November 11 showed the presence of spermatozoa. The first female was permanently removed from the cage on December 5. The second and third females were removed on December 29 and replaced by two other females. On January 16, 1948, however, the second female was returned to the cage. The male was found copulating again with her on February 6, 13, and 16. She was removed to a separate cage on February 25, and on April 24 aborted two embryos. A vaginal smear taken on February 24 from one of the females placed in the breeding cage on December 29 revealed an abundance of spermatozoa, indicative of recent copulation. No signs of copulation were observed after this date.

Captive bats were observed to copulate both on the floor of the cage and while hanging upside down on the vertical screen walls. On all occasions the male lay over the back of the female but was never seen holding her with his mouth. The uropatagium of the female was pushed to one side at such times. All copulations were observed during daylight hours. No vaginal plug was ever found in the female although a jelly-like substance, rich in spermatozoa, was found in the vagina immediately after copulation.

To determine what effect out-of-door temperature might have upon the breeding activities of pallid bats in San Francisco, 3 females and a male were placed in an outdoor flight cage on September 25, 1947. These bats, like those kept in the indoor flight cage, had been captured 5 days earlier in eastern San Luis Obispo County. One of the females was observed copulating with the male on October 31, and on November 4, 5, 6, 10, 13, 14, 17, 18, 19, and 24. There were no indications that either of the other 2 females bred. A fourth female was placed in the cage on November 1 and was observed copulating with the male on November 12. No sexual activity was observed during December and on the 29th of that month the 4 females were removed and 3 other females were placed in with the male. There was no further indication of breeding, however, on the part of these bats during the succeeding months. The air temperatures, in degrees Fahrenheit, for San Francisco as compiled by the United States Department of Commerce, Weather Bureau, in the *Monthly Weather Review*, for October, 1947, to February, 1948, are shown as follows:

	Mean	Mean Maximum	Mean Minimum
October	62°	68°	56°
November	55.3°	61°	49°
December	51°	56°	46°
January	54.7°	62°	48°
February	50.8°	57°	45°

Summarizing these observations on the breeding of pallid bats in captivity, therefore, it would appear that those maintained in the indoor laboratory cage, where the extreme ranges in daily temperature were from 50°F. to 65°F., copulated during the months of November, December, January, and February. Bats kept in an outdoor flight cage in San Francisco bred only from the end of October to the end of November. The mean minimum temperatures for these two months were 56°F. and 49°F., respectively. There was no indication of breeding during December, January, and February when the mean minimum temperatures were 46°F., 48°F., and 45°F., respectively. None of the captive bats kept in this outside flight cage went into dormancy in the usual sense of the word as applied to colonial bats. They ate regularly during the winter and, on all except the coldest nights, appeared to be active.

Field observations failed to show that pallid bats breed in September. There is some evidence (cf. Seasonal Behavior) that the summer colonies break up in October. During this month and up until the middle of November these bats were found in smaller aggregations, in one instance just a pair, and in places where they were not observed in summer. Females with spermatozoa in the vaginal passage were examined on October 22. On the basis of these few facts, combined with those obtained from captive pallid bats kept in an outdoor cage in San Francisco, it would appear that in central California this species breeds at least in the latter part of October and in November.

Very little is known regarding the whereabouts, and nothing pertaining to the sexual behavior, of pallid bats in the wild during the months of December, January, February, and March. Certain North American species of colonial, vespertilionid bats that have been studied in winter have been found to show signs of periodic activity during the season of dormancy. This, as has been noted, was also true of captive pallid bats kept without food at temperatures ranging from 38°F. to 50°F. Possibly during these brief periods of activity copulation occasionally occurs. Pearson, Koford, and Pearson (1952) have shown that in *Corynorhinus rafinesquei* in California copulation occurs mostly during the winter months. These authors also indicate that the males are much more active that the females at this season and probably copulate with the females while the latter are torpid.

The literature on this subject has been carefully summed up by Hartman (1933), Baker and Bird (1936), Wimsatt (1945), and others. With most vespertilionid bats occurring in the Northern Hemisphere copulation takes place principally in the fall of the year prior to hibernation. There may or may not be occasional copulations by bats aroused from dormancy during the winter, and again in spring just prior to or about the time of ovulation. *Miniopterus schreibersii,* which was studied by Courrier (1927) in France is, of course, an exception to this rule. In this species copulation and ovulation both occur in the fall. Fertilization takes place immediately and pregnancy lasts over the winter until spring. *Miniopterus australis,* studied by Baker and Bird (1936) in the New Hebrides, breeds in the spring at which time fertilization occurs. *Miniopterus* is considered exceptional in so far as the family Vespertilionidae is concerned. Bats of the family Rhinolophidae behave essentially like most of the Vespertilionidae in that they copulate in the fall of the year and ovulate in the spring. On the other hand, phyllostomatid bats (Hamlett, 1935) and molossid bats (Hartman and Cuyler, 1927; Sherman, 1937) that have been studied, copulate in the spring at the time of ovulation.

During this study an attempt was made to determine whether or not spring or late winter insemination is necessary, both for normal development and for fertilization, in the pallid bat. Guthrie and Jeffers (1938) induced ovulation in *Myotis lucifugus* in December and January by injections of hypophyseal extract and found that normal development did not follow, whereas ovulations induced in February were followed by normal cleavage and the formation of blastodermic vesicles. These authors, as well as Miller (1939) in his paper on the reproductive cycle of male bats, concluded that this difference in the activation reaction was conditioned by the introduction of fresh sperm during the late winter copulations. Pearson, Koford, and Pearson (1952, p. 299) conclude that in *Corynorhinus rafinesquei* "there is a refractory period during autumn and early winter during which ovulation does not normally occur. . . ." They further conclude "that ovulation is not readily induced by removing *Corynorhinus* from hibernation to warm rooms before mid-February, but that injections of pregnancy urine bring about ovulation at this time."

On December 5, 1947, a female pallid bat that had been captured on September 20, and was known to have copulated repeatedly during November, was removed from a cool room in which she had been caged with a male and placed alone in a cage in a heated greenhouse where the temperature ranged from 75°F. to 78°F. It was hoped that this would induce ovulation. On February 26, 1948, she gave birth to one young which was reared successfully. The total elapsed time from the date on which the female had been placed in the warm room until parturition occurred was 83 days. Although the time of ovulation was not known, it is probable that some days elapsed between the time the bat was placed in a warm environment and the time of ovulation. Normal development apparently occurred in this instance in midwinter.

Wimsatt (1944) has shown that fall and early winter insemination can effect fertilization in the spring in *Myotis lucifugus* and *Eptesicus fuscus.* Ryberg (1947), apparently unaware of Wimsatt's (1944) work, mentions two instances in which females of *Nyctalus noctula* were captured in the fall after hibernation had commenced and kept cool and isolated during the winter. He states (p. 149) that "Long after they had awakened in the spring, they began, gradually, without any possibility of copulating again, to show signs of pregnancy."

To determine whether or not late winter or spring insemination is necessary for fertilization in the pallid bat, a female that was known to have copulated on November 12, 1947, and may have copulated subsequently, was isolated from all males in an outdoor flight cage on December 29, 1947. Sometime between the night of May 21 and the morning of May 24, 1948, she gave birth to one young. The young was dead when found on May 24, but appeared normal as regards development. Presumably, as often happens in captivity, the female deserted the young at birth and the latter died from neglect. Birth in this instance occurred nearly five months after the female was isolated from any males. As has already been indicated and will be shown subsequently, this greatly exceeds the gestation period of this species.

Vaginal smears were taken approximately once a week from 12 captive females, between December 4, 1947, and June 4, 1948, to determine whether or not any epithelial changes could be observed and correlated with the reproductive cycle. Between June and December, 1948, smears were taken once or twice a month. Small, sterile, rubber spatulas were used and each smear was diluted with a drop of Ringer's solution on a slide. The slides were examined with an 8 mm. objective and ×7 ocular. Some of the bats used in the study were kept out-of-doors, others in a warm laboratory, and others in a refrigerated room during the winter and early spring of 1947–48, to see if environmental temperature had any effect.

In general it was found that squamous epithelial cells were present all year around. Although occasional cornified cells were noted during all months of the year, they were found in abundance from the end of

January until early in May. The greatest number of cornified cells, in proportion to nucleated epithelial cells, were observed in smears from bats kept at lower environmental temperatures. Leucocytes appeared in March and April, varying in time of appearance with the individual. There was no continuous invasion of the vagina by leucocytes during these months but rather a sudden rise and fall in the count. It was suspected that the appearance of leucocytes in numbers might be associated with ovulation, but this was not determined. An occasional leucocyte was found in early May, after which not one was seen. Guthrie (1933) noted large numbers of leucocytes in the vaginal passage in *Myotis lucifugus* at the time of ovulation in the spring.

As has previously been stated, a captive female that had bred was removed from a moderately cool environment and placed in a warm room on December 5, 1947. Eighty-three days later she gave birth to a normal young. It was believed that the increased temperature induced ovulation and that the gestation period may have been about eighty days, possibly less, depending upon the time required for the maturing of the follicle (see Guthrie and Jeffers, 1938). In order to further check the gestation period, 15 female pallid bats were secured on April 15, 1949, in eastern San Luis Obispo County. This was 5 days after the first appearance of bats at this colony site. They were transported to San Francisco and on the following day 4 were killed and their reproductive tracts fixed in Bouin's fluid. After this material was sectioned and stained it was found that one female had recently ovulated, possibly within 24 hours, although no tubal egg could be found. The ruptured follicular cavity had not as yet formed a corpus luteum. The three other reproductive tracts contained blastocysts in one or both horns of the uterus. In each instance implantation was beginning to occur on the antimesometrial side of the uterus and the beginnings of chorionic villi were evident on the side of the trophoblast next to the inner cell mass. A thin, single-celled layer of entoderm adhered to the underside of the inner cell mass and the inner surface of the trophoblast of each blastocyst. In one embryo the amniotic cavity had not as yet made its appearance. In each of the others a small amniotic cavity was present. In the most advanced embryo the flattened embryonic disc was quite apparent. To state the age of these embryos is a difficult matter. When compared with the macaque, studied by Heuser and Streeter (1941), which has a gestation period of 168 days, they are comparable to the development attained between the 9th and 12th days following ovulation. One would expect more rapid growth in the case of a mammal having a shorter gestation period. Guthrie and Jeffers (1938), however, found free uterine blastocysts in *Myotis lucifugus* at what was estimated to be the tenth day following ovulation induced by injections of hypophyseal extract. If such slow development occurs in vespertilionid bats under natural conditions following normal ovulation in the spring, the most advanced embryos found in *Antrozous* females killed on April 16 might be estimated to be about 12 days of age. This would indicate that 3 of the 4 females ovulated sometime during the first week of April. Two more females were killed on May 2. One contained a single embryo, the other contained 3 embryos, 2 in the right horn of the uterus and 1 in the left. All 4 embryos appeared to be at about the same stage of development, but only 1 was removed from the foetal membranes for measurement. This individual had a crown-rump length of 5 mm. The others were preserved intact in their foetal membranes for future study. On May 18, 2 more females were killed. One contained 1, the other 2 embryos. Each embryo had a crown-rump measurement of 12 mm. On May 23 another female aborted 2 young. The first of these was eaten by the parent. The second dropped to the floor of the cage and was removed and preserved for later study. It measured 16 mm. from crown to rump. On June 1, one of the remaining 6 females showed obvious signs of illness and was found dead on June 6. A post-mortem examination indicated that she had probably died on June 4. One horn of the uterus contained an 18 mm. embryo. On June 7 two of the females gave birth to 2 normal young each. Another female produced 2 young between the evening of June 10 and the morning of June 13, another female gave birth to 1 young on June 14. The remaining female failed to produce young. Although she may not have been pregnant, there is the possibility that she aborted at some time without this fact being observed by the writer.

Thus, if we assume that the 4 females that gave birth to young between June 7 and 14 ovulated sometime between April 4 and 15, as was believed true of the 4 females killed on April 16, the possible maximum and minimum gestation periods would be 71 and 53 days respectively. It is reasonable to presume, however, that those that bore young first were the first to ovulate. This would indicate an average gestation period of about 9 weeks. However, Pearson, Koford, and Pearson (1952) as well as Eisentraut (1937) earlier, have suggested that environmental temperature, in so far as it affects the temperature of the mother, may influence the length of the gestation period in certain species of bats. Consequently it is possible that extended periods of cold weather in spring, during the time of pregnancy, may prolong the gestation period in this species.

Wimsatt (1945) estimated the gestation period for *Myotis lucifugus* to be between 50 and 60 days. Pearson, Koford, and Pearson (1952) indicate that in *Corynorhinus rafinesquei* the gestation period may vary from 59 to 100 days, depending upon the mother's body temperature. Sherman's (1937) studies on *Tadarida cynocephala,* a molossid bat of the southeastern United States, led him to conclude that the gestation period in that species is between 11 and 12 weeks.

Birth and Growth of Young

Number of young per female: Records of 28 females, from San Luis Obispo and Kern counties, that either bore young or were pregnant (4 captured with 2 young each, 10 gave birth to young in captivity, 14 had embryos *in utero*) are as follows: 1 female had 3 embryos, 20 females had 2 embryos or young each, 7 females had 1 embryo or young each. This is an average of 1.8 young per bearing female.

Hall (1946, p. 165) indicates that uterine examinations of 13 pregnant pallid bats taken in Nevada showed that 11 contained 2 embryos each, 1 contained 3 embryos, and 1 contained 1 embryo. Bailey (1936, p. 392) mentions 2 females taken in a cave in Nevada, each with 2 young attached. Burt (1934, p. 397) records 4 females taken at Indian Springs, Nevada, on the nights of June 2 and 7, 1929. Three of the females each contained a single, well-developed embryo and the other female contained 2 embryos measuring 22 mm. J. Grinnell (1914, p. 263) records a female taken along the Colorado River with 2 embryos. H. Grinnell (1918, pp. 352 and 356) records a female taken at San Bernardino, California, with 3 embryos and another taken at Painted Rock, San Luis Obispo County, California, with 2 embryos. Grinnell and Storer (1924, p. 61), on examining 19 females captured on May 27, 1915, at Snelling, Merced County, California, found that 15 contained 2 embryos each, 3 had 1 embryo each, and one was not pregnant.

Two young, therefore, appears to be the usual number borne annually by most female pallid bats. Occasionally there may be only one young and rarely three. It is difficult to understand how females of this species could successfully rear 3 young since they only possess 2 nipples and the young seem to hold tightly to these for the first few days after birth. It is possible that in females with 3 embryos one is resorbed prior to birth, although resorption of advanced embryos has quite justifiably been questioned by Ryberg (1947, p. 139).

Dates of birth: The time at which the young are born varies with individual females in the same colony and seemingly to some extent with locality and year.

On May 10, 1947, 7 female pallid bats were captured 2½ miles northwest of Carneros Spring in Kern County. Two had newly born young clinging to them and the remaining 5 were pregnant. The latter had all given birth to young in captivity by May 14. These were the earliest seasonal field records for young obtained during this study. The region where these bats were found, however, was the hottest and most arid part of the entire area where observations were carried on.

On June 6, 1948, 10 pregnant females were captured at random from a colony 4½ miles northeast of Shandon, San Luis Obispo County. This locality was about 27 miles northwest of the site of the colony previously mentioned and was in a region that may be described as cooler and less arid in summer. Two of the females were prepared as study skins and each was found to contain 2 nearly full-term foetuses. The latter averaged 45.5 (45–46) mm. in total length and 2.55 (2.5–2.6) grams in weight. Four of the females were released 2 days later and the remaining 4 gave birth to young in captivity between June 14 and 23. On the evening of the same day the 10 pregnant females were captured, a lactating female pallid bat was shot near Carneros Spring in Kern County. It was thought that she had probably borne young several weeks previously. On the following day, June 7, 1948, 35 female pallid bats were taken from a colony on the northwestern edge of the Carrizo Plain, San Luis Obispo County. All were palpated before being released and were found to be in advanced stages of pregnancy.

Four females captured at the colony 4½ miles northeast of Shandon on April 15, 1949, gave birth to young in captivity between June 7 and 14. Two pregnant females were captured at this colony on April 14, 1951. One was killed on April 17 and found to contain 2 embryos with a crown-rump length of 7 mm. which indicated a much earlier ovulation date than was suspected for females taken from this same colony on April 16, 1949 (cf. table II). The second female was killed on May 25 and found to have 2 foetuses about ready for birth.

From the foregoing evidence, therefore, there is some indication that the time of parturition in eastern San Luis Obispo and Kern counties varies from year to year within the same colony. It is quite possible that early warm spring weather may be conducive to early seasonal appearance and ovulation. Within any one colony in this region such data as were gathered indicate that, in any one year, all the females bear their young within a period of several weeks.

On June 13, 1951, 10 young were secured from a colony of pallid bats inhabiting an attic at Stanford University, Santa Clara County, California. The smallest individual was about half grown and unable to fly. Its age was estimated at about 3½ weeks. Three others were about three-fourths grown but not quite able to fly. The remaining 6 had body measurements within the range of adults and could fly well. The oldest was believed to be about 6 weeks of age and probably was born the first week in May.

Regarding reproduction of this species in Nevada, Hall (1946, p.

165) may be quoted as follows: "It was noted that the embryos taken on May 17 measured only 3 mm. from crown to rump. The female taken on June 4, 6 miles south of St. Thomas, had two embryos nearly ready for birth, and the embryos found on June 7 at Indian Springs (Burt, 1934: 397) also were nearly full term. On June 15, 1939, in crevices in the roof of a cave 10 miles west and 5 miles south of Fallon, Alcorn (MS) found about fifty females nearly every one of which had one or two young securely fastened to her mammae. Bailey (1936: 392) found a colony of females with young in the same cave on June 27, 1927. The young of one female, he thought, were but one day old. Burt (1934: 397) mentions young bats nearly full grown taken at Indian Springs on August 2 and 3; our specimen taken August 7, west of Lahontan Dam, is of similar age. It appears that young ordinarily are born in the first half of June."

Sex ratio of young: Fifty young comprising 25 taken at random from colonies in the wild, 21 born in captivity, and 4 removed from the uteri of pregnant females just prior to birth, were carefully examined to determine sex. Twenty-seven were males and 23 were females. These figures seem to indicate a nearly equal sex ratio at birth.

Parturition: The relatively meager literature on parturition in the Chiroptera has been fairly well summed up by Ramakrishna (1950). In general, breech presentation is characteristic of most of the species of Microchiroptera in which birth has been observed, exceptions having been noted in the case of *Nyctalus noctula* by Daniell (1834) and *Hipposideros speoris* by Ramakrishna (1950). Observations made on a number of captive pallid bats giving birth to young indicate that parturition in this species conforms in general to the pattern thought to be characteristic of the suborder.

During the period of labor and birth captive females hung upright. The uropatagium was curled ventrally at such times to form a basket and thus prevent the young from falling to the floor when born. The period of labor varied from a few minutes to nearly two hours. Females respired rapidly when in labor and frequently uttered notes of pain during contractions. When females had 2 young, the time recorded between the births varied from 12 to 65 minutes. All births observed were by breech. The rump and tail of the young, with uropatagium folded over the ventral part of the body, emerged first. As soon as the hind feet of the young were free they seemed to be used to further assist emergence by pushing against the mother's body. On several occasions a female was seen to sever the umbilical cord by biting it and later to eat the placenta when it was expelled. In most instances, however, the females were not under observation at times when this occurred. If the placenta was not found in the cage the following day it was believed that the female had eaten it. Females that did not consume the placentae refused to accept their young and either killed the latter by biting them or else let them fall to the floor of the cage. The refusal of some captive females to accept their young was thought to be an abnormal condition associated with confinement in an artificial environment.

Females that behaved in what might be termed a normal manner licked their young frequently during the process of birth and then licked them thoroughly immediately after birth. One mother was seen to extend the wings of her newborn young with her mouth so that she could lick the membranes. Newly born bats seemed capable of climbing of their own accord to the mother's mammary glands. They used their thumbs, hind feet, and mouths to hold on to their mother's fur and pull themselves up. The female usually would assist by nuzzling the young. After a young bat became attached to its mother's nipple the female would envelop the young with her plagiopatagium so that the baby could no longer be seen. The young oriented itself in the same direction as the parent. Consequently, if she hung upside down the offspring did likewise.

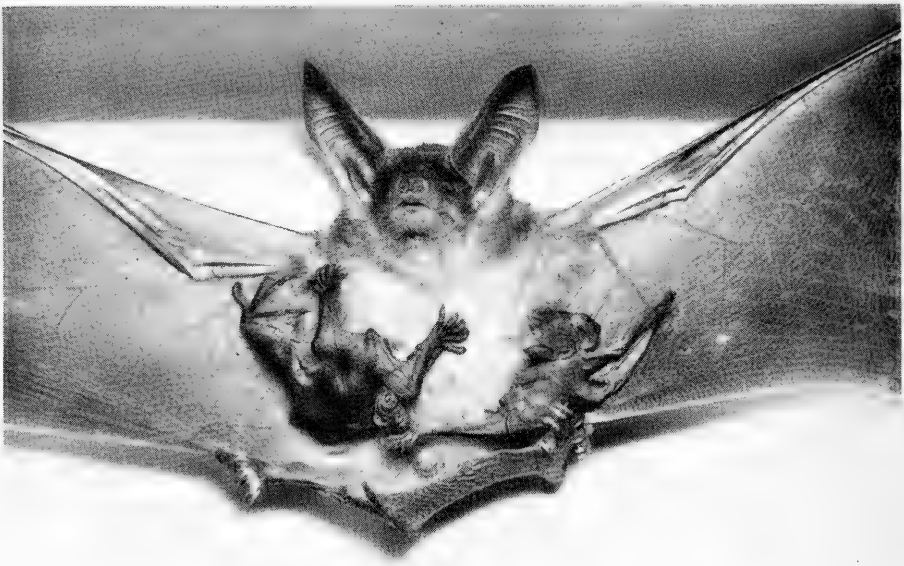


Figure 24. Female pallid bat with young 2 days old. Photographed by Lionel T. Berryhill, May 15, 1947.

Since young bats hold on very tightly to their mother's nipples (fig.

24) it is often very difficult to remove them to take body measurements. Furthermore, disturbance of this sort occasionally results in a female refusing to accept her young. Consequently, few newborn young were measured in captivity. However, the following selected measurements were made of two seemingly healthy young males a few hours after birth (figures in parentheses represent percentages of corresponding average adult male measurements): Total length, 48, 50 (42 per cent); tail length, 13, 15 (37 per cent); hind foot, 9, 10 (71 per cent); ear from notch, 8, 9 (30 per cent); forearm, 17, 18 (31 per cent). Their weights were 2.9 and 3.3 grams.

Development of young: At the time of birth young pallid bats have their eyes closed and their ears folded down tightly against the sides of the head. The skin of the body and the appendages is pink and to the unaided eye appears naked. When examined under a low-power microscope a few hairs will be found on the following parts: on either side of the head extending as a band from behind the rhinarium almost to the base of the antitragus, along the margin of the lower jaw, on the flight membranes immediately dorsal to the humerus and femur, and on the underside of the distal phalanges of the toes.

The information relating to growth of young given in the following paragraphs is based upon bats born and reared in captivity, unless otherwise stated (figs. 25 to 28). It is quite possible that under such circumstances the normal rate of growth and development may have been affected. A number of young developed malformations of the bones before maturity, presumably as a result of dietary deficiencies. Others seemed fairly normal.

By the fourth day of postnatal life the regions on which minute hairs could be detected had increased considerably so as to include an area extending from the tip of the tail anteriorly to the posterior lumbar region, then forward on either side of the body to the posterior thoracic area. Hairs also occurred on the dorsal surface of the legs and toes as well as on the wings from the thumb to the shoulder. These hairs could barely be seen by the naked eye at this time. By about the tenth day scanty fur was clearly evident on most of the upper parts of the body, excluding the area between the shoulders. Heaviest pelage was present on the lower back although the longest hairs were to be found on the posterior sides of the lower jaw.

The eyes, which were closed at time of birth, opened between the eighth and tenth days. The ears, although capable of being raised slightly by the third or fourth day, were not held erect until about the time the eyes opened. The tragus was pressed against the main body of the pinna thus closing the external auditory canal until this time.

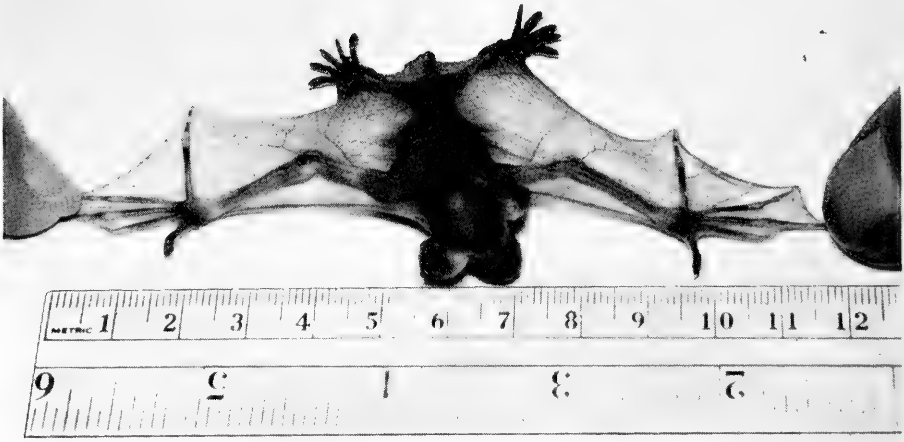


Figure 25. Dorsal view of a 3-day-old male pallid bat. Photographed by Lionel T. Berryhill, May 15, 1947.

Figure 26. Ventral view of a 3-day-old male pallid bat. Photographed by Lionel T. Berryhill, May 15, 1947.

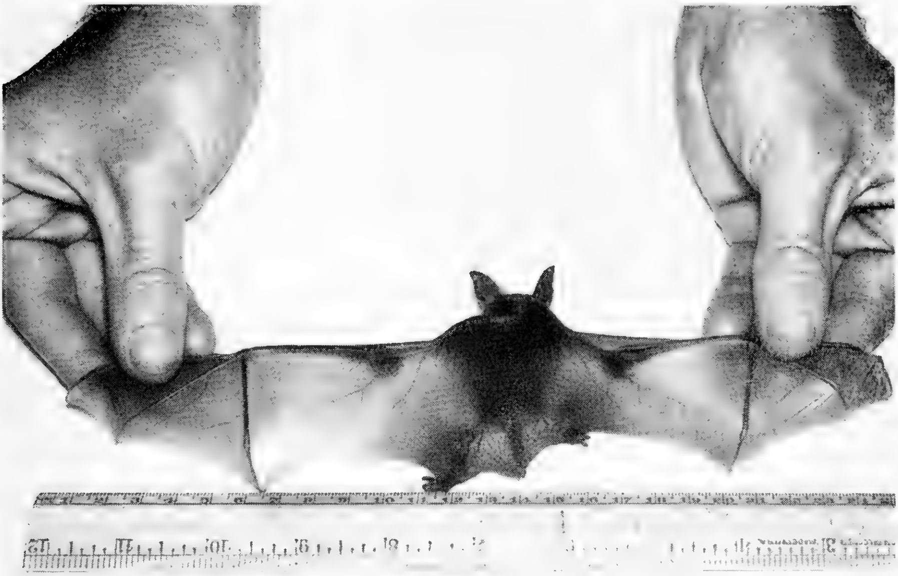


Figure 27. Dorsal view of a female pallid bat 30 days old. Photographed by Lionel T. Berryhill, June 9, 1947.

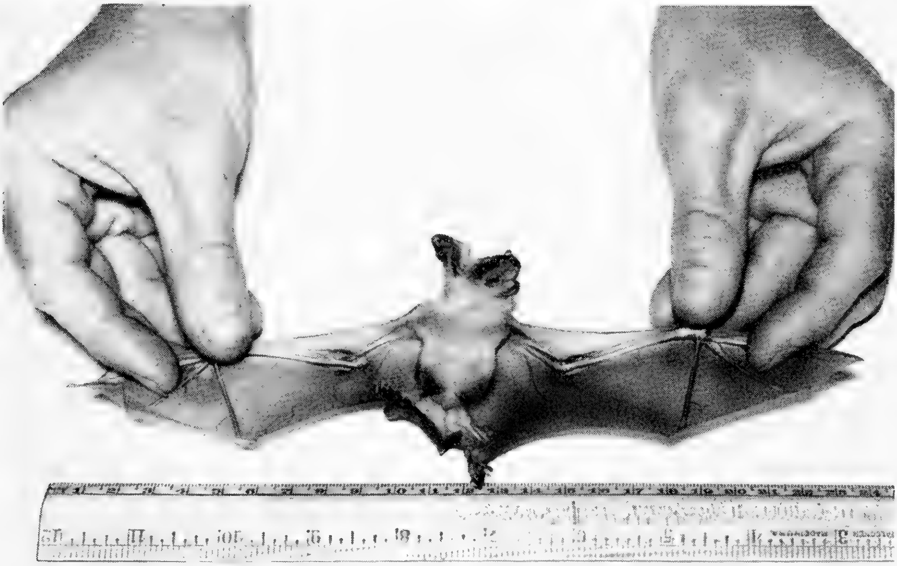


Figure 28. Ventral view of a female pallid bat 30 days old. Photographed by Lionel T. Berryhill, June 9, 1947.

Captive young were observed to exhibit fear when 10 days old. When a hand was placed near a young bat at this age it would draw back and utter an intimidation buzz.

Whether or not females in the wild carry their young with them when they forage at night was not determined. On several occasions females that were disturbed at their daytime roosts were observed flying away with their young attached. Griffin (1940, p. 182) states that "For the first three or four days after birth young of *Myotis lucifugus* are usually carried by the mother as she hunts." By the time young captive pallid bats were two weeks old they ceased hanging onto the mother during the daytime. The parent, however, kept the young beneath the plagiopatagium until they were too large for this arrangement and were forced to hang beside her.

By the eighteenth day a short, scanty pelage was seen on all of the upper parts of the body, except for the intershoulder area, and to a limited extent on the ventral parts. The skin, which was pink during the first week, had gradually darkened on the body wherever hair was present. The flight membranes had become somewhat grayish with the darkest coloration evident along the top of the tail and dorsal parts of the legs.

By the time the young were 24 days old the fur was sufficiently dense and long to obscure the skin except between the shoulders, a region relatively bare even in adults. At this age the general color of the dorsal pelage was much darker than that of adults. This resulted largely from the fact that only the darkly pigmented distal parts of the hairs had made their appearance and the light basal portions had not as yet grown out. The fur on the ventral parts of the body was a pale cream-buff, somewhat like that of the adult but with a more grayish cast. The flight membranes appeared vinaceous.

By the thirty-fourth day the light basal parts of the hairs of the dorsal parts of the body were evident. The young still appeared much darker than adults. Apart from the intershoulder area, which acquired a scanty growth of hair at 2½ months, pelage changes after the first month seemed only to involve increase in length of hairs.

The earliest age that a captive-born young was observed to fly was 7 weeks. However, wild-taken young whose measurements were approximately similar to captive young 6 weeks old were capable of flying quite well. It is significant perhaps in this regard to note that captive young began eating some mealworms by the time they were 6 weeks old, although they continued to nurse for several more weeks until the female would finally discourage this by keeping away from them or by threatening them when they came close to her.

The pelage of young when they have attained adult size is indistinguishable from that of adults in new pelage. Many pallid bats were examined in the field in September and October. It seems highly probable that some of these must have been young of the year. If so, however, they could not be distinguished from adults at this season on the basis of external characters.

Tooth replacement: There is considerable variation in the deciduous dentition of the Chiroptera. Some bats, such as members of the family Rhinolophidae, possess deciduous teeth only in embryonic life. These teeth are reportedly absorbed prior to birth. Others retain their deciduous teeth for some weeks of postnatal life. In certain groups these teeth have the form of simple, straight spicules. In others they may be noticeably recurved. In some members of the family Vespertilionidae the deciduous teeth are not only recurved but may possess one or two accessory cusps.

The complete number of deciduous teeth in the pallid bat is 22, represented by the formula: i $\frac{2}{3}$, c $\frac{1}{1}$, pm $\frac{2}{2}$. As pointed out by Miller (1907, p. 20) this represents the maximum number known to occur in the order and is characteristic of a number of species of vespertilionids. In studying the sequence of appearance of the permanent teeth in this species the following material was used: 14 alcoholic specimens, ranging from foetuses nearly ready for birth to young 8 days old; 7 captive-born young whose dental development was followed from birth until the permanent dentition was acquired; 7 skulls of young whose approximate ages were determined on the basis of information derived from a study of young bats born and reared in captivity.

An examination of nearly full-term foetuses indicates that the first deciduous teeth to erupt through the gums are the upper and lower canines. Shortly following this the upper and lower incisors erupt, although in some specimens the first pair of upper incisors were somewhat slower than the others in appearing. This in general is the condition at time of birth, although Barrett-Hamilton (1910, p. 14) states that young bats, with the exception of members of the family Rhinolophidae, are born with complete deciduous dentition. The upper and lower premolars in *Antrozous* usually do not make their appearance until the third to the fifth day of postnatal life. In several newborn young, however, these teeth were in the process of breaking through the gums. By the early part of the second week the deciduous teeth are about fully grown out.

There is considerable individual variation in the shape of these teeth, especially the canines and premolars. The crowns of the upper and lower incisors possess a definitely trifid pattern with a main central cusp and two smaller accessory cusps, one on either side. The canines, both upper and lower, may vary from a condition in which three distinct cusps are present to one in which only two cusps are faintly indicated. The upper premolars may be trifid, bifid, or have the crown more or less truncate in shape. The last form is most often seen in pm ^{2}. Pm $_{\bar{1}}$ is generally trifid while pm $_{\bar{2}}$ varies like the upper premolars. The cusps, which are shaped like small hooklets, are curved inward. This is most pronounced, however, on the upper and lower incisors.

The deciduous dentition has long been considered to represent a primitive type of dentition. This was the contention of Winge (1941) and is a view generally held by mammalogists. However, with respect to the clasping type of deciduous teeth found in certain bats one must concur with Spillman (1927, p. 251) who describes this as a remarkable specialization not found in any other living or fossil groups of mammals. Such teeth unquestionably enable the young to hold tightly

Table III

Sequence of loss of deciduous teeth in *Antrozous pallidus*.

Upper teeth	*Age at which lost*	*Lower teeth*	*Age at which lost*
Pm^2	5 weeks	I$_{\bar{1}}$	2–3 weeks
Pm^1	5–6 weeks	I$_{\bar{2}}$	2–3 weeks
I^1	6–8 weeks	I$_{\bar{3}}$	4 weeks
I^2	6–8 weeks	Pm$_{\bar{1}}$	4 weeks
C	8–10 weeks	Pm$_{\bar{2}}$	5–8 weeks
		C	8–9 weeks

Table IV

Order of appearance of permanent teeth in *Antrozous pallidus*.

Upper teeth	*Age at time of eruption*	*Lower teeth*	*Age at time of eruption*
C	4 weeks	C	3 weeks
I	4 weeks	I$_{\bar{1}}$	4 weeks
		I$_{\bar{2}}$	4 weeks
Pm	4 weeks	Pm$_{\bar{1}}$	4 weeks
M^1	5 weeks	Pm$_{\bar{2}}$	4 weeks
M^2	5 weeks	M$_{\bar{1}}$	4 weeks
		M$_{\bar{2}}$	5 weeks
M^3	5 weeks	M$_{\bar{3}}$	5 weeks

to the mother's nipple when she is in flight. It is very difficult to remove young from the mother during the first week or two following birth without injuring the mouth of the former or the mammary gland of the latter.

The permanent dental formula for the pallid bat is: i $\frac{1}{2}$, c $\frac{1}{1}$, pm $\frac{1}{2}$, m $\frac{3}{3} = 28$. These teeth erupt through the gums internal to the deciduous teeth and for the most part their appearance precedes the loss of the deciduous teeth (tables III and IV). Certain of the latter teeth are present for some time after the young are weaned.

Food

Since pallid bats do not emerge from their daytime retreats until dusk it is difficult to make observations on their foraging habits. Some observers report that these bats go directly to water after taking to the air in the evening. Bailey (1936, p. 391), referring to members of this species, says: "At early dusk they begin to come out and usually fly directly to the nearest still water where they drink by repeatedly dipping to the surface, then begin their search for insect food." Nelson (1918, p. 493) makes the following statement regarding pallid bats: "Often when camping at desert waterholes, I have seen them come in just before dark to drink, scooping up water from the surface while in flight, and then circling back and forth over the damp ground at an elevation of a few yards for the capture of some of the insects common in such places."

Whether or not drinking water is essential for pallid bats is not known. However, only one of the summering colonies located during the course of this study was situated more than half a mile from known available fresh water. In this instance there was a spring 2½ miles away and it is possible that there may have been sources of water nearer. In captivity bats regularly drank water.

When foraging, members of this species generally fly fairly low and, as has long been known, frequently alight on the ground to capture food. Burt (1934, pp. 397–398) observed these bats usually flying 3 or 4 feet above the ground when foraging. He also records them frequently alighting on a lawn to capture June beetles *(Polyphylla)* in front of a ranch house at Indian Springs in southern Nevada during the summer. Nelson (1918, p. 493) reported the capture of a pallid bat that lit on the ground in an apple orchard in northern Arizona. The bat had caught a Jerusalem cricket *(Stenopelmatus fuscus)* and was so engrossed in its prey that it was readily picked up by the nape of the neck. Huey (1936, p. 285) records 2 pallid bats caught in mouse traps set for desert rodents in Mono County, California, on August 2,

1932. Since many insects, especially pinacate beetles and desert crickets, had been observed coming to the bait the night before it was suspected that the bats had come to feed on the insects.

Nearly every pile of droppings beneath the day and night roosts of pallid bats examined during this study contained numerous remains of Jerusalem crickets which, of course, are flightless and must have been captured on the ground. The remains of scorpions were also frequently found in such places.

Mr. Eben McMillan, who contributed so much to this study, placed some clean grain sacks beneath some grain tanks where pallid bats were noted hanging up at night on the Pinole Ranch on the Carrizo Plain in San Luis Obispo County, on October 22, 1949. Each morning during the succeeding week the sacks were examined and then cleaned. On each of the first six mornings fresh remains of Jerusalem crickets were found beneath the roost.

On October 23, 1949, the writer found numerous insect remains beneath a pallid bat roost along San Juan Creek, 9 miles west of Simmler, San Luis Obispo County. Some of these were saved and later identified as parts of the following insects: Orthoptera: *Stenopelmatus* probably *fuscus;* Coleoptera: *Polyphylla* probably *decimlineata, Romaleum simplicicolle, Prionus californicus, Eleodes acuticauda.*

Mrs. Grinnell (1918, p. 355) records the remains of Jerusalem crickets and sphinx moths as being most numerous during the summer on the floor of a barn loft occupied by pallid bats at Glendora, Los Angeles County, California. A sample of insect remains dropped by these bats in this same loft in September contained parts of the following: Orthoptera: *Stenopelmatus* sp., *Microcentrum* sp., *Gryllus* sp.; Lepidoptera: *Deilephila* [*Celerio*] *lineata;* Coleoptera: *Prionus californicus, Ligyrus gibbosus.*

Hatt (1923, p. 261) lists the arthropod remains found with droppings beneath a pallid bat roost in September at Mission San Antonio de Padua, Monterey County, California. Most of these were Jerusalem crickets *(Stenopelmatus fuscus)* and scorpions *(Anuroctonus phaiodactylus)*. A few other insect fragments identified included a grasshopper *(Schistocerca* sp.) and a beetle *(Polyphylla decimlineata).*

Borell (1942, p. 337) records the remains of grasshoppers *(Melanoplus differentialis* and *Schistocerca shoshoni),* large June bugs, and one large ground beetle, found beneath a night roost used by pallid bats near Albuquerque, New Mexico.

It is not known whether bats of this species regularly prey upon animals other than arthropods. Engler (1943, pp. 96–97), however, records captive pallid bats which were observed to eat western skinks *(Eumeces skiltonianus),* a Sonoran desert gecko *(Coleonyx variegatus),* and were suspected of eating the head and neck of a Mexican free-tailed bat *(Tadarida mexicana)*. It seems likely that starvation was responsible for such deviation from an insectivorous diet, although, as the author suggests, it is possible that small night lizards may locally be preyed upon by pallid bats.

It is practically impossible to determine the quantity of food consumed nightly by insectivorous bats in the wild. In captivity, however, it is a relatively simple matter to ascertain the amount of food a bat consumes each night, although this does not necessarily represent the amount that would be taken under natural conditions. Mathias and Seguela (1940, pp. 15–19) found that *Myotis mystacinus* and *M. myotis,* fed on fly pupae, consumed an amount equal to about one-third of their own weight daily. Ramage (1947, p. 61) found that several species of *Myotis,* kept in small flight cages, ate about one-half their own weight in fly pupae or termites each night while a specimen of *Eptesicus fuscus,* kept in a small cage in which it could not fly, ate an amount equal to about one-third of its weight per day. As noted by that author the quantity of food eaten by captive bats varies greatly on different nights.

From May 25 to September 23, 1947, records were kept of the amount of food (meal worms in this instance) consumed by 3 captive pallid bats (1 male, 2 females) each night. The food was weighed before being placed in the cage each afternoon and the amount left in the morning was again weighed. From May 25 to August 13, the bats were kept indoors 41 per cent of the time. After this date they were constantly kept indoors. From May 25 to June 1 the average amount of food consumed per bat per night was 3.5 grams. The average weight per bat was 29.2 grams on June 5. During July the average amount of food consumed per bat per night was 4.2 grams. The average weight per bat was 29.9 grams on July 10. From August 1 to August 13, the nightly food consumption per bat was 4.5 grams. The average weight per bat was 28.3 grams on August 7. From August 14 to September 23 each bat ate an average of 4.7 grams of food per night. During this period, however, there was a marked increase in the weight of the bats. Their average weights on various dates were as follows: August 21, 30.6 grams; August 29, 32.3 grams; September 5, 33.5 grams; September 12, 35.1 grams; September 19, 38.6 grams. During this entire period of nearly 4 months these bats were given adequate amounts of food daily as evidenced by remains found in the mornings. The marked increase in weight during the latter part of August and in September may be attributed partly to lack of sufficient exercise, although there is evidence that under natural conditions bats show an increase in weight at this time of year.

While captive bats were principally fed meal worms during the early phases of this study and a prepared diet later (see p. 168) certain other kinds of animal food were occasionally offered them. They accepted the pupae of the following species of Diptera: *Lucilia sericata, Calliphora erythrocephala,* and *Calliphora vomitoria.* On one occasion an omnivorous looper moth *(Sabulodes caberata)* was accepted by a bat and eaten. On another occasion two of three snails *(Helix aspersa)* were eaten by captive pallid bats. California oak moths *(Phryganidia californica)* were refused.

No personal field observations were obtained relating to the manner in which these bats eat large insects. On several occasions, however, live Jerusalem crickets, held by forceps, were offered captive bats that were hanging head downward in cages. In each instance the bat viciously bit the insect, then reversed its position in the cage so that its head was uppermost. The tail and uropatagium were then curled up ventrally so as to form a basket before eating began. The position of the bat at such times was similar to that assumed by females when giving birth to young. The basket served to prevent the food falling to the ground until all desirable parts were consumed. The head and legs of these large crickets were discarded. Borell (1942, p. 337) observed a pallid bat in a similar position when it was eating a grasshopper, and Pittman (1924) described a similar posture for captive individuals of *Myotis lucifugus* when they were eating moths.

PARASITES

The following ectoparasites were found on pallid bats from San Luis Obispo and Kern counties:

HEMIPTERA

Cimex pilosellus Horváth. Western bat bedbug.

DIPTERA

Basilia antrozoi (Townsend). Bat fly.

SIPHONAPTERA

Myodopsylloides palposa (Rothschild). Flea.

ACARINA

Ornithodoros stageri Cooley and Kohls.	Tick.
Ornithodoros sp.	Tick.
Spinturnix sp.	Mite.
Steatonyssus sp.	Mite.

Cimex pilosellus Horváth. On May 10, 1947, a western bat bedbug was found on a pallid bat captured at a daytime roost in western Kern County. On April 14, 1951, while trying to remove some pallid bats from a colony along San Juan Creek, 9 miles west of Simmler, San Luis Obispo County, a western bat bedbug was found adhering to a net which had been poked into the crevice housing the bats.

Basilia antrozoi (Townsend). This species of nycteribiid was found to be fairly common on pallid bats. Nearly all bats of this species examined during the spring and summer months had a few, usually 1 to 3, of these parasitic flies on them. The greatest number found on any one individual was 8. It is possible that these parasites are less numerous in the fall as only 10 out of 37 pallid bats captured on September 20, 1947, in San Luis Obispo County had flies on them. These insects showed a preference for the sides of the bodies of their hosts. They usually remained hidden in the fur unless disturbed. This species has previously been reported from *Antrozous* as well as from several other genera of the Family Vespertilionidae (cf. Stiles and Nolan, 1931, p. 648).

Myodopsylloides palposa (Rothschild). Fleas were found to be relatively uncommon parasites on pallid bats. They were recorded only three times and no more than one flea was ever found on a bat. Two specimens were collected on September 20, 1947, and another was secured on April 14, 1951.

Ornithodoros sp. Many pallid bats collected or examined in the field during the months of September and October were rather heavily infested with ticks. Those ticks collected during these months proved to be larval forms of the genus *Ornithodoros* but could not be identified as to species. A count was made of the number of ticks found on a group of 37 bats secured in San Luis Obispo County on September 20, 1947. Eleven of the bats were free of these parasites. The other 26 had the following numbers, respectively: 1, 1, 1, 1, 1, 1, 1, 1, 2, 2, 3, 3, 3, 3, 4, 4, 4, 4, 6, 6, 8, 10, 12, 13, 16, 26. Ticks were most frequently found on the sides and back of the neck, the shoulders, and sides of the body. Larval ticks were not found on the flight membranes.

On April 14, 1951, while capturing bats from a colony living beneath a loose slab of rock on a cliff 9 miles west of Simmler, San Luis Obispo County, a large number of adult ticks were found crawling up the perpendicular face of the cliff beneath the roost. In probing for the bats the ticks had apparently been dislodged and they were attempting to return to the crevice that housed the bats. A number of these were saved and proved to be *Ornithodoros stageri* Cooley and Kohls. An examination of 11 pallid bats captured here at this time revealed the presence of larval ticks on 5 individuals. The number of ticks found on the bats varied from 1 to 11. A single adult tick of the above-mentioned species was found boring into the upper surface of the uropatagium of one bat.

Spinturnix sp., and *Steatonyssus* sp. Mites were commonly noted on the flight membranes of nearly all bats examined in the field and those kept in the laboratory. All those identified were either adults or nymphs of the genera *Spinturnix* or *Steatonyssus*. Individuals of the latter genus were generally more abundant than those of the former. The number of mites on pallid bats usually far exceeded that of all of the other ectoparasites together. No marked seasonal fluctuation in numbers was apparent.

Although no Diptera belonging to the family Streblidae were observed by the writer on any bats of this species, Jobling (1949) records *Trichobius corynorhini* Cockerell from *Antrozous* in California. This streblid primarily parasitizes bats of the genus *Corynorhinus* (cf. Kessel, 1952) but has been recorded on several other kinds of cave-inhabiting bats. Possibly the occurrences of these flies on bats other than those of the genus *Corynorhinus* is accidental.

Enemies

As was noted by the late Dr. Glover M. Allen (1939, p. 280), "Bats have few enemies." There is no indication that pallid bats are an exception to this rule. It is likely that their greatest enemy among the vertebrates is man who dislikes having small native mammals living in his attics and barns.

Pallid bats are occasionally preyed upon by owls. Baker (1953, p. 253) records the remains of 6 pallid bats found in pellets, belonging to either horned owls (*Bubo virginianus*) or barn owls (*Tyto alba*), collected in central Coahuila, Mexico.

Since bats of this species emerge rather late in the evening there is little likelihood of their being attacked by diurnal birds of prey under ordinary conditions. If a colony is subjected to occasional daytime disturbance, however, there is some evidence that individuals may be captured or at least harassed by small hawks. On June 9, 1948, 7 banded bats that had been captured 3 days previously at a colony about 30 miles away, were released at 7:00 a.m. close to a cliff bordering San Juan Creek in central eastern San Luis Obispo County. There were numerous crevices and small caves in the nearby cliff and several of the bats immediately flew to one of the recesses. Another lit on a sandstone outcrop and was immediately attacked by a Brewer blackbird *(Euphagus cyanocephalus)*. It was able to avoid the attacker by scrambling into a narrow crevice. The other bats flew around the cliff and disappeared from sight. Shortly afterwards, however, a sparrow hawk *(Falco sparverius)* flew over the cliff with an object that appeared to be a pallid bat in its claws. Another instance of a hawk attacking a bat of this species was observed about midday on October 23, 1949, at a rocky outcrop along the northwestern edge of Carrizo Plain in San Luis Obispo County. On this occasion while the writer and several others were attempting to capture a group of bats, found beneath a loose slab of sandstone, in order to band them, 2 individuals escaped. One of these was suddenly attacked, as it was flying about in the sunlight, by a sharp-shinned hawk *(Accipiter striatus)* that had been perched in a nearby oak. The bat evaded the hawk and dropped safely into a crevice out of sight.

Allen (1939, p. 288) mentions a record, supplied him by B. Patterson Bole, of a snake (species not known) that was found to have captured a pallid bat in California. As suggested by Allen it is not surprising that bats of this species, which occasionally alight on the ground, are sometimes caught by nocturnal snakes.

Hatt (1923, p. 261) in commenting on the remains of scorpions found beneath pallid bat roosts, a fact confirmed during the present study, makes the following comment: "It is difficult to understand how these bats capture the scorpions without being severely hurt or killed, for the venom of this scorpion is poisonous enough to kill most mammals of this size and the physical injury of the injection alone should be a serious matter to so small an animal. These scorpions are able to bend the postabdomen to such a wide range of positions that it would seem impossible that the bat could avoid being stung the greater number of times that it captured such prey. It is possible then that this bat is immune to the venom of a scorpion." Nothing is known regarding the immunity of pallid bats to scorpion venom or their ability to kill such arthropods without being stung. Consequently, the scorpion must be considered as a potential enemy until proved otherwise.

SUMMARY

Pallid bats are to be found in colonies during the spring, summer, and early fall months. The number of individuals in established summer colonies observed during this study was found to vary from approximately 30 to 100. Daytime roosts may be in crevices in rocks or recesses in man-made structures, such as houses, barns, and bridges. Night roosts, where bats may rest or consume insects that they have captured, are usually close to the day roosts.

In central California pallid bats arrive at the summer colonies by the latter part of March or early April. Members of both sexes may be present in a colony. The annual molt may occur any time between May and August. Summer colonies start to break up in October. During this month and early November the bats are found in smaller groups, often in situations where they are not to be seen earlier in the year. Little is known regarding the whereabouts of pallid bats in winter. They are absent from their summer retreats and have not been observed flying about at night. There is no evidence, however, that any extended migration occurs. The few records available of wintering individuals indicate that single bats or small groups pass the winter, probably in a torpid condition, in remote recesses. A study was made on the effect of lowered environmental temperatures on captive pallid bats. Individuals kept in a dark room without food for 144 days at temperatures ranging from 40°F. to 50°F. lost an average of 27.6 per cent in body weight or 0.193 per cent per day per bat. Bats kept under similar conditions but at temperatures between 38°F. and 40°F. for 119 days lost an average of 24.96 per cent in body weight or 0.209 per cent per day per bat. Bats kept for extended periods of time at low temperatures without food occasionally drank water and did not survive unless high relative humidity was maintained in their cages.

Seasonal fluctuations were apparent in the body weights of pallid bats. Lowest weights were recorded for bats when they first made their appearance in summer colonies in the spring. Males gained weight for several weeks, then maintained a fairly constant level until the end of summer. Females continued to gain weight until they had their young. Members of both sexes again showed an increase in weight in the fall.

Several kinds of vocal utterances are produced by pallid bats, including an intimidation note, a squabble, a directive call, chittering, and a plaintive note associated with pain. The odor, produced by glands on either side of the nose of these bats is distinctive and it is suggested that it may serve as a defense mechanism to repel other animals.

Studies were made on the flight of these bats, using slow motion pictures and stills made with the aid of an electronic flash. The motion of a bat's wing is essentially the same as that of a bird's wing in forward flight. The downstroke is downward and forward and the upstroke is upward and backward. The upstroke is considered to be less efficient in the bat's wing than in the bird's wing. The feathers of the latter can be separated to minimize air resistance at such times while any comparable action is impossible for the wing of a bat. Other actions on the part of a bat in flight, however, compensate for this loss in efficiency. In straight flight the pallid bat makes 10 to 11 wing strokes per second.

Members of this species emerge rather late in the evening. In early June the illumination was less than 0.1 foot candles when the bats emerged. In the latter part of September they were recorded emerging earlier in relation to sunset.

Observations in the field as well as on captive bats kept in outdoor cages indicate that in central California pallid bats copulate at least during the months of October and November. Copulation was observed in captive bats maintained in indoor laboratory cages between the months of November and February, inclusive. Nothing is known regarding the sexual behavior of these bats in the wild in winter.

Early winter ovulation was induced in a female that was placed in a warm room on December 5 and kept there until she gave birth to a normal young 83 days later on February 26. Another female that was known to have copulated was isolated in an out-of-door flight cage on December 29. Nearly 5 months later she gave birth to one young, showing that in this instance later winter or early spring insemination was not necessary for fertilization. Vaginal smears of captive females revealed the presence of nucleated epithelial cells all year around. Cornified cells were most abundant from the end of January until early in May. Leucocytes were noted only in March and April and their presence was thought to be associated with ovulation. The gestation period is estimated to average about 9 weeks. The average number of young for 28 females was 1.8. Young are born between early May and the middle of June, the time varying with year, locality, colony, and with individual females in a colony. The sex ratio at birth is nearly equal.

Females hang upright at time of parturition and the young are born by breech presentation. It would appear that under normal circumstances the female cuts the umbilical cord and eats the placenta. Young pallid bats have their eyes closed at birth and their ears are folded down tightly against the sides of the head. The body is essentially naked. The eyes open between the eighth and the tenth day of postnatal life, at which time the ears can be erected. Fear is exhibited by the tenth day. Fur is evident on parts of the body by the fourth day and has nearly grown out by the end of one month. Captive-born young were observed flying when 7 weeks old but it is believed that young in the wild can fly at an earlier age.

The deciduous incisors and canines have erupted through the gums at time of birth and the premolars generally make their appearance when the young are 3 to 5 days old. The first deciduous teeth to be lost are the premolars and the last are the canines. Many of the permanent teeth appear before their deciduous predecessors are lost.

Large orthopterous insects and beetles appear to be important in the diet of pallid bats. Some of the insects eaten are flightless species which must be picked up from the ground.

Mites of the genera *Spinturnix* and *Steatonyssus*, ticks, and wingless dipterans belonging to the family Nycteribiidae are common ectoparasites on pallid bats. Less common are fleas and bat bedbugs. These bats have few known enemies. If disturbed enough to fly during the daytime they may be attacked by small hawks. There is one record of a pallid bat found in the stomach of a snake, and another of remains of pallid bats found in owl pellets.

LITERATURE CITED

Abdulali, H.

1949. Sex ratios in Indian bats. *Journal of the Bombay Natural History Society*, vol. 48, pp. 423–427.

Alcorn, J. R.

1944. Notes on the winter occurrence of bats in Nevada. *Journal of Mammalogy*, vol. 25, pp. 308–310.

Allen, G. M.

1939. Bats. x + 368 pp., frontispiece + 57 text figs. Harvard University Press, Cambridge, Massachusetts.

Allen, J. A.

1903. List of mammals collected by Mr. J. H. Batty in New Mexico and Durango, with descriptions of new species and subspecies. *Bulletin of the American Museum of Natural History*, vol. 19, pp. 587–612.

Aymar, G. C.

1935. Bird flight. xii + 294 pp., illustrated. Dodd, Mead, and Company, New York.

Bailey, V.

1905. Biological survey of Texas. *United States Department of Agriculture, Biological Survey, North American Fauna*, no. 25, pp. 1–222, 16 pls., 24 text figs., 1 map.

1931. Mammals of New Mexico. *United States Department of Agriculture, Bureau of Biological Survey, North American Fauna*, no. 53, pp. 1–412, 22 pls., 58 text figs.

1936. The mammals and life zones of Oregon. *United States Department of Agriculture, Bureau of Biological Survey, North American Fauna*, no. 55, pp. 1–416, 51 pls. (nos. 2–52), 102 text figs., 1 map.

Baker, J. R., and T. F. Bird

1936. The seasons in a tropical rain-forest (New Hebrides).—Part 4. Insectivorous bats (Vespertilionidae and Rhinolophidae). *Journal of the Linnean Society of London*, vol. 40, pp. 143–161, 1 pl., 1 text fig., 3 tables.

Baker, R. H.

1953. Mammals from owl pellets taken in Coahuila, Mexico. *Transactions of the Kansas Academy of Science*, vol. 56, pp. 253–254.

Barrett-Hamilton, G. E. H.

1910–1911. A history of British mammals. Vol. 1, pts. I–IV, xvi + 263 pp., 20 pls., 26 figs. Gurney and Jackson, London, England.

Borell, A. E.

1942. Feeding habit of the pallid bat. *Journal of Mammalogy*, vol. 23, p. 337.

Burt, W. H.

1934. The mammals of southern Nevada. *Transactions of the San Diego Society of Natural History*, vol. 7, pp. 375–427, 1 map, 2 tables.

1938. Faunal relationships and geographic distribution of mammals in Sonora, Mexico. *Miscellaneous Publications, Museum of Zoology, University of Michigan*, no. 39, pp. 1–77, 26 maps, 2 tables.

1945. The Bunker bat in Oklahoma. *Journal of Mammalogy*, vol. 26, p. 309.

Cahalane, V. H.

1939. Mammals of the Chiricahua Mountains, Cochise County, Arizona. *Journal of Mammalogy*, vol. 20, pp. 418–440, 2 text figs., 1 map.

Constantine, D. G.

1946. A record of *Dasypterus ega xanthinus* from Palm Springs, California. *Bulletin of the Southern California Academy of Sciences*, vol. 45, p. 107.

Courrier, R.

1927. Etude sur le déterminisme des caractères sexuels secondaires chez quelques mammifères à activité testiculaire périodique. *Archives de Biologie*, Paris, tome 37, pp. 173–334, pls. 9–13, 10 text figs.

Dalquest, W. W.

1938. Bats in the state of Washington. *Journal of Mammalogy*, vol. 19, pp. 211–213.

1947. Notes on the natural history of the bat *Corynorhinus rafinesquii* in California. *Journal of Mammalogy*, vol. 28, pp. 17–30, 1 map.

Daniell, G.

1834. [Observations on the habits of the pipistrelle, *Vespertilio pipistrellus*, and the noctule, *Vespertilio noctula*, in captivity.] *Proceedings of the Zoological Society of London*, vol. 2, pp. 129–132.

Davis, W. B.

1944. Notes on Mexican mammals. *Journal of Mammalogy*, vol. 25, pp. 370–403, 1 text fig.

DURRANT, S. D.

1952. Mammals of Utah. *University of Kansas Publications, Museum of Natural History*, vol. 6, pp. 1–549, 91 text figs., 30 tables.

EISENTRAUT, M.

1937. Die Wirkung niedriger Temperaturen auf die Embryonalentwicklung bei Fledermäusen. *Biologisches Zentralblatt*, Bd. 57, pp. 59–74, 3 figs.

ENGLER, C. H.

1943. Carnivorous activities of big brown and pallid bats. *Journal of Mammalogy*, vol. 24, pp. 96–97.

FOLK, G. E., JR.

1940. Shift of population among hibernating bats. *Journal of Mammalogy*, vol. 21, pp. 306–315, 1 text fig., 1 table.

FRIES, S.

1879. Ueber die Fortpflanzung der einheimischen Chiropteren. *Zoologischer Anzeiger*, Bd. 2, pp. 355–357.

GALAMBOS, R., and D. R. GRIFFIN

1942. Obstacle avoidance by flying bats; the cries of bats. *Journal of Experimental Zoology*, vol. 89, pp. 475–490, 6 figs.

GRIFFIN, D. R.

1940. Notes on the life histories of New England cave bats. *Journal of Mammalogy*, vol. 21, pp. 181–187, 2 tables.

1946. Mystery mammals of the twilight. *National Geographic Magazine*, vol. 90, pp. 117–134, illustrated.

GRIFFIN, D. R., and J. H. WELSH

1937. Activity rhythms in bats under constant external conditions. *Journal of Mammalogy*, vol. 18, pp. 337–342, 3 figs.

GRINNELL, H. W.

1918. A synopsis of the bats of California. *University of California Publications in Zoology*, vol. 17, pp. 223–404, pls. 14–24, 24 text figs.

GRINNELL, J.

1914. An account of the mammals and birds of the lower Colorado Valley with especial reference to the distributional problems presented. *University of California Publications in Zoology*, vol. 12, pp. 51–294, pls. 3–13, 9 text figs.

1933. Review of the recent mammal fauna of California. *University of California Publications in Zoology*, vol. 40, pp. 71–234.

GRINNELL, J., and T. I. STORER

1924. Animal life in the Yosemite. xviii + 752 pp., 62 pls., 65 text figs. University of California Press, Berkeley.

Guthrie, M. J.

1933. The reproductive cycles of some cave bats. *Journal of Mammalogy*, vol. 14, pp. 199–216, 1 table.

Guthrie, M. J., and K. R. Jeffers

1938. The ovaries of the bat *Myotis lucifugus lucifugus* after injection of hypophyseal extracts. *Anatomical Record*, vol. 72, pp. 11–36.

Hall, E. R.

1946. Mammals of Nevada. xi + 710 pp., frontispiece + 11 pls., 485 text figs. University of California Press, Berkeley and Los Angeles.

Hamlett, G. W. D.

1935. Breeding habits of the phyllostomid bats. *Journal of Mammalogy*, vol. 16, pp. 146–147.

Hartman, C. G.

1933. On the survival of spermatozoa in the female genital tract of the bat. *Quarterly Review of Biology*, vol. 8, pp. 185–193.

Hartman, C. G., and W. K. Cuyler

1927. Is the supposed long life of the bat spermatozoa fact or fable? (Abstract) *Anatomical Record*, vol. 35, p. 39.

Hatfield, D. M.

1937. Notes on the behavior of the California leaf-nosed bat. *Journal of Mammalogy*, vol. 18, pp. 96–97.

Hatt, R. T.

1923. Food habits of the Pacific pallid bat. *Journal of Mammalogy*, vol. 4, pp. 260–261.

Heuser, C. H., and G. L. Streeter

1941. Development of the macaque embryo. *Contributions to Embryology*, vol. 29, no. 181, *Carnegie Institution of Washington Publication* 525, pp. 15–55, pls. 1–33, 5 text figs.

Hibbard, C. W.

1934. *Antrozous bunkeri*, a new bat from Kansas. *Journal of Mammalogy*, vol. 15, pp. 227–228.

Hinde, R. A.

1952. The behaviour of the great tit *(Parus major)* and some other related species. x + 201 pp., 11 figs. E. J. Brill, Leiden.

Huey, L. M.

1936. Desert pallid bats caught in mouse traps. *Journal of Mammalogy*, vol 17, pp. 285–286.

JOBLING, B.

1949. Host-parasite relationship between the American Streblidae and the bats, with a new key to the American genera and a record of the Streblidae from Trinidad, British West Indies (Diptera). *Parasitology*, vol. 39, pp. 315–329, 3 text figs., 2 tables.

KESSEL, E. L.

1952. New host records for *Trichobius corynorhini* (Diptera: Streblidae). *Wasmann Journal of Biology*, vol. 10, pp. 7–8.

KRUTZSCH, P. H.

1946. Some observations on the big brown bat in San Diego County, California. *Journal of Mammalogy*, vol. 27, pp. 240–242.

MATHIAS, P., et J. SEGUELA

1940. Contribution à la connaissance de la biologie des chauves-souris. *Mammalia*, tome 4, pp. 15–19.

McKEE, E. D.

1932. Big-eared bat in the Grand Canyon. *Journal of Mammalogy*, vol. 13, p. 71.

MILLER, G. S., JR.

1897. Revision of the North American bats of the family Vespertilionidae. *United States Department of Agriculture, Division of Biological Survey, North American Fauna*, no. 13, pp. 1–135, 3 pls., 40 text figs.

1907. The families and genera of bats. *United States National Museum Bulletin* 57, xvii + 282 pp., 14 pls., 49 text figs.

MILLER, R. E.

1939. The reproductive cycle in male bats of the species *Myotis lucifugus lucifugus* and *Myotis grisescens*. *Journal of Morphology*, vol. 64, pp. 267–295, 3 pls., 2 text figs.

NELSON, E. W.

1918. Smaller mammals of North America. *National Geographic Magazine*, vol. 33, pp. 371–493, illustrated.

1921. Lower California and its natural resources. *Memoirs of the National Academy of Sciences*, vol. 16, pp. 1–194, 35 pls.

OLSON, A. C., JR.

1947. First record of *Choeronycteris mexicana* in California. *Journal of Mammalogy*, vol. 28, pp. 183–184.

ORR, R. T.

1940. The rabbits of California. *California Academy of Sciences, Occasional Papers*, no. 19, pp. 1–227, 10 pls., 30 text figs.

1945. A study of captive Galapagos finches of the genus *Geospiza*. *Condor*, vol. 47, pp. 177–201.

1950. Unusual behavior and occurrence of a hoary bat. *Journal of Mammalogy*, vol 31, pp. 456–457.

PEARSON, O. P., M. R. KOFORD, and A. K. PEARSON

1952. Reproduction of the lump-nosed bat *(Corynorhinus rafinesquei)* in California. *Journal of Mammalogy*, vol. 33, pp. 273–320, 6 pls., 7 text figs., 1 table.

PITTMAN, H. H.

1924. Notes on the feeding habits of the little brown bat *(Myotis lucifugus). Journal of Mammalogy*, vol. 5, pp. 231–232, pl. 23.

RACEY, K.

1933. Pacific pallid bat in British Columbia. *The Murrelet*, vol. 14, p. 18.

RAMAGE, M. C.

1947. Notes on keeping bats in captivity. *Journal of Mammalogy*, vol. 28, pp. 60–62.

RAMAKRISHNA, P. A.

1950. Parturition in certain Indian bats. *Journal of Mammalogy*, vol. 31, pp. 274–278, 1 pl.

RIDGWAY, R.

1912. Color standards and color nomenclature. iii + 43, 53 pls. (Published by the author, Washington, D. C.)

ROLLINAT, R., and E. TROUESSART

1896. Sur la reproduction des chauves-souris. *Mémoirs de la Société Zoologique de France*, tome, 9, pp. 214–240.

RYBERG, O.

1947. Studies on bats and bat parasites. xvi + 319 pp., 55 pls., 44 maps, 2 tables, 1 diagram. Svensk Natur, Stockholm.

SETZER, H. W.

1950. Albinism in bats. *Journal of Mammalogy*, vol. 31, p. 350.

SHERMAN, H. B.

1937. Breeding habits of the free-tailed bat. *Journal of Mammalogy*, vol. 18, pp. 176–187, 5 text figs., 1 table.

SIMPSON, G. G.

1945. The principles of classification and a classification of mammals. *Bulletin of the American Museum of Natural History*, vol. 85, xvi + 350 pp.

SPILLMAN, FR.

1927. Beiträge zur Eiologie des Milchgebisses des Chiropteren. *Abhandlungen von der Senckenbergischen Naturforschenden Gesellschaft, Frankfurt am Main*, Bd. 40, pp. 249–255, 8 figs.

STILES, C. W., and M. O. NOLAN

1931. Key catalogue of parasites reported for Chiroptera (bats) with their possible public health importance. *National Institute of Health Bulletin*. no. 155 (United States Public Health Service), pp. 603–742.

Storer, J. H.

1948. The flight of birds analyzed through slow-motion photography. *Cranbrook Institute of Science, Bulletin,* no. 28, xv + 94 pp., frontispiece, 176 text figs., 3 tables. Bloomfield Hills, Michigan.

Storer, T. I.

1931. A colony of Pacific pallid bats. *Journal of Mammalogy,* vol. 12, pp. 244–247, 1 table.

Swarth, H. S.

1929. The faunal areas of southern Arizona: a study in animal distribution. *Proceedings of the California Academy of Sciences,* 4th series, vol. 18, pp. 267–383, pls. 27–32, 7 text figs.

Warren, E. R.

1910. The mammals of Colorado, xxxiv + 300 pp., 81 text figs., 2 maps. G. P. Putnam's Sons, New York and London.

Wimsatt, W. A.

1944. Further studies on the survival of spermatozoa in the female reproductive tract of the bat. *Anatomical Record,* vol. 88, pp. 193–204.

1945. Notes on breeding behavior, pregnancy, and parturition in some vespertilionid bats of the eastern United States. *Journal of Mammalogy,* vol. 26, pp. 23–33, 1 table.

Winge, H.

1941. The interrelationships of the mammalian genera. [Translated from Danish by E. Deichmann and G. M. Allen.] Vol. 1, xii + 418 pp., 1 pl. C. A. Reitzels, Copenhagen.

PROCEEDINGS
OF THE
CALIFORNIA ACADEMY OF SCIENCES
FOURTH SERIES
Vol. XXVIII, No. 5, pp. 247-321, Figs. 1-45 January 7, 1954

THE TROMBICULID MITES OF JAPAN

BY
MANABU SASA
Institute for Infectious Diseases
University of Tokyo
AND
E. W. JAMESON, Jr.
Department of Zoology, University of California,
Davis, California

The classical studies of tsutsugamushi disease in Japan long ago drew first attention to the chigger (trombiculid mite) fauna of that country, and for many years this disease and the associated chiggers were investigated and reported upon by Japanese workers. Because many of their reports are difficult to obtain and because of the previous lack of interest in chiggers, the western world had only a vague understanding of the Japanese species. Our knowledge of Oriental chiggers was greatly advanced during World War II: many species were described and the status of many previously named species was clarified. Following the war, there has been a resurgence in the taxomomic study of chiggers in Japan, and many new species have been described from this small country. Unfortunately, most of these descriptions are in Japanese and in journals of a limited distribution outside of Japan.

Studies upon which this paper is in part based were conducted under contract no. DA–49–007–MD–242, between the Regents of the University of California and the Medical Research and Development Board, office of the Surgeon General, Department of the Army. The work was initiated while the junior author was associated with the 406th Medical General Laboratory and Far East Medical Research Unit in Japan during the period January-October, 1952. Logistical support for the preparation of the illustrations was supplied by the U. S. Army Hospital, 8164 Army Unit, APO 9, by special arrangement with the above-mentioned organizations.

This paper presents a brief summary of the chigger fauna of Japan. Omissions are inevitable for new species are being described from Japan almost every month; and before publication of this paper our list will be outdated. Nevertheless, we hope that the keys, diagnoses, and data with these illustrations will simplify the identifications of Japanese chiggers.

It would be premature to discuss the Japanese trombiculid fauna with regard to chiggers elsewhere; but from the list of chiggers already known from Japan, however, some comments are justified. We have listed here 6 genera and 45 species of chiggers in the Japanese fauna. Of the 45 species known from Japan, 27 are endemic: in view of the widespread geographic distribution of species of chiggers generally, it is remarkable that more than half of the known species in this tiny country seem to be confined to it.

The most important genus is *Trombicula.* Worthy of comment is the abundance both in numbers of individuals and in species of the subgenus *Leptotrombidium;* this group contains 18 species in Japan, and 14 of these are apparently confined there. Although the subgenus *Leptotrombidium* is well represented elsewhere in the Orient, there seems to be no such concentration of species in such a small area. This situation presents an interesting contrast to the fauna of adjacent North America where the group is rather scarce. The subgenus *Trombiculindus,* containing one species in Japan, is represented by four other species in the tropical Orient, and thus seems to be an austral element. The subgenus *Miyatrombicula* contains a single species *(T. (M.) kochiensis)* found on the islands of Skikoku, Kyushu, and southern Honshu. In contrast to the other groups of *Trombicula,* the subgenus *Neotrombicula,* with six species in Japan, contains two species that are also found in North America, and four species that occur on the adjacent Asiatic mainland. The single species of the subgenus *Eutrombicula (wichmanni)* in Japan is widespread and common in the southern Orient; avian hosts of this species make a wide geographic distribution easily understandable.

In Japan the genus *Euschöngastia* is scarce, and known from only four species; one of these *(E. ikaoensis)* has been found also in southern Korea. This state of affairs is vastly different from what obtains in North America where *Euschöngastia* is one of the dominant groups.

The genus *Neoschöngastia,* its members characteristically parasites of birds, is represented by six species in Japan; five of these occur elsewhere in the world, two of them having been described from North America. Theoretically, of course, they can be as widely distributed as their hosts; and because most species of *Neoschöngastia* appear not to be confined to a single species of host, they may easily be more widely distributed than any one host.

When the chigger faunas of the world are more completely known, we can better classify that of Japan. As we know it today, on the specific level the trombiculid fauna of Japan seems not closely allied to that of any other region: the large number of endemic species justifies labelling the fauna as typically Japanese: that is, the species seem no more closely related to Oriental species than they are to Nearctic species. Generically, Japanese chiggers seem more typically Palaearctic than Oriental in affinities; many genera of the tropical Orient are not known to occur in Japan.

The illustrations in this paper were made in Kyoto, Japan, and represent the holotype wherever such was available. The staff of artists was under the direct supervision of Mr. K. Yamazaki; Mr. Yamazaki was assisted by Mr. A. Shimazoe, Mr. K. Daishoji, Mr. S. Shibata, Mr. M. Endo, Miss F. Tamara, and Miss C. Tanaka. For the excellence of their painstaking labors we are deeply appreciative. We wish to thank also Miss Y. Yoshida, technician and interpreter, who prepared the bulk of the material collected during the course of this study.

Dr. Mitosi Tokuda was of great assistance in collecting many of the specimens used in this paper. Special thanks are due Mr. Seiichi Toshioka

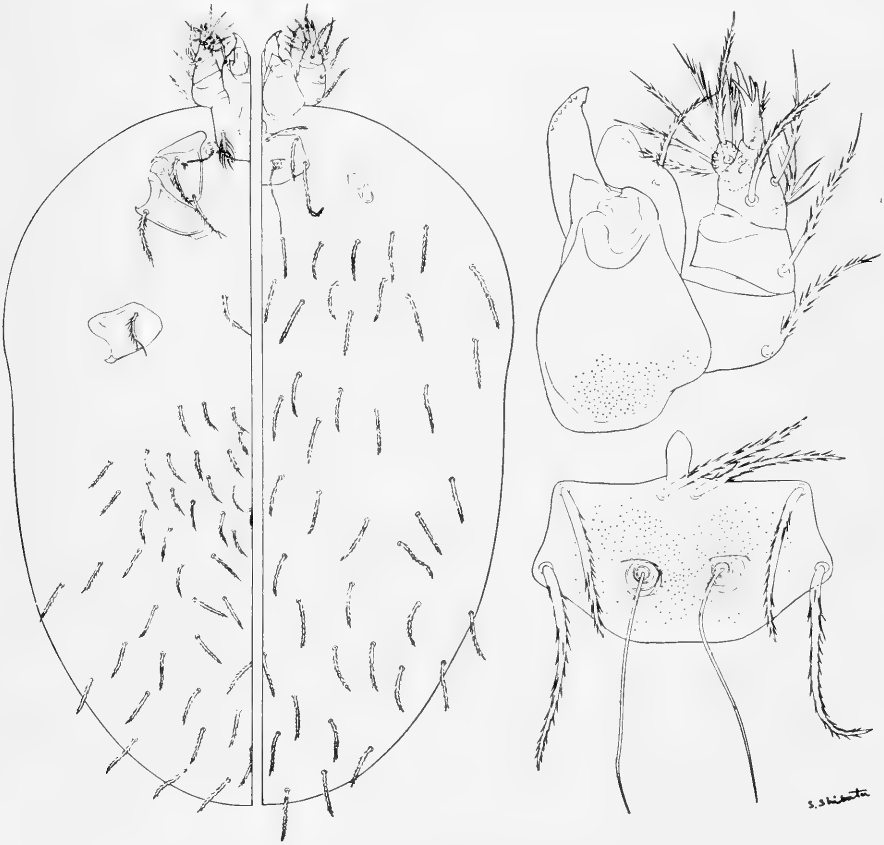


Fig. 1 *Acomatacarus yosanoi*

for his invaluable service in checking many of the scutal measurements used in this paper; and for collecting a large amount of the data on host and geographic distribution of Japanese chiggers.

We are greatly indebted to Dr. James M. Brennan for much council given during the preparation of this paper; and to Major Paul W. Oman, MSC, under whose administration this work was done.

Key to Genera and Subgenera of Chiggers in Japan

1\. Coxa I with two setae .... genus *Acomatacarus*
— Coxa I with one seta 2
2\. With no anteromedian seta .... genus *Gahrliepia* 3
— With one anteromedian seta 4
3\. Scutum with four marginal setae .... subgenus *Walchia*
— With more than four setae, some not marginal .... subgenus *Gahrliepia*
4\. Sensillae expanded distally 5
— Sensillae flagelliform .... genus *Trombicula* 7
5\. Scutum partly submerged beneath the integument .... genus *Neoschöngastia*
— Scutum entirely on the surface of the integument 6
6\. Coxa II with a single seta .... genus *Euschöngastia*
— Coxa II with more than a single seta .... genus *Doloisia*
7\. Posterolateral setae greatly expanded, foliate .... subgenus *Trombiculindus*
— Posterolateral setae slender 8
8\. Coxa III with several setae .... subgenus *Miyatrombicula*
— Coxa III with a single seta 9
9\. With one or more mastitarsalae III 10
— With no mastitarsalae III 12
10\. Scutum roughly pentagonal; palpal claw three-pronged .. subgenus *Neotrombicula*
— Scutum rectangular; palpal claw two-pronged 11
11\. Axial prong (of palpal claw) external (or dorsal); with 20 or 22 dorsal setae .... subgenus *Eutrombicula*
— Axial prong (of palpal claw) internal (or ventral); with 30 or more dorsal setae .... ungrouped species
12\. Palpal femoral and genual setae nude; galeal seta feathered; no mastitarsalae III; sternal setae 2–2; coaxal setae 1–1–1; scutum more or less rectangular .... subgenus *Leptotrombidium*
— Without the above combination of characters .... ungrouped species

Acomatacarus yosanoi Fukuzumi and Obata, 1953
(Figure 1)

Acomatacarus yosanoi Fukuzumi and Obata, 1953, Kitasato Archives of Experimental Medicine, vol. 26, no. 2, pp. 1–22.

Diagnosis: All palpal setae feathered; ventral tibial seta with long branches, other palpal setae very short, fine branches. Palpal claw four-pronged. Galeal seta with fine branches. Chelicera with a row of about seven small teeth along the dorsal edge. Scutum with general conformation and characteristics of the genus; posterior margin more or less three sided. Sensillary bases about on a line with the posterolateral setae. Bases of sensillae with a small number of very small barbs; sensillae nude distally. With 80 or more dorsal setae, more or less scattered. A single pair of sternal

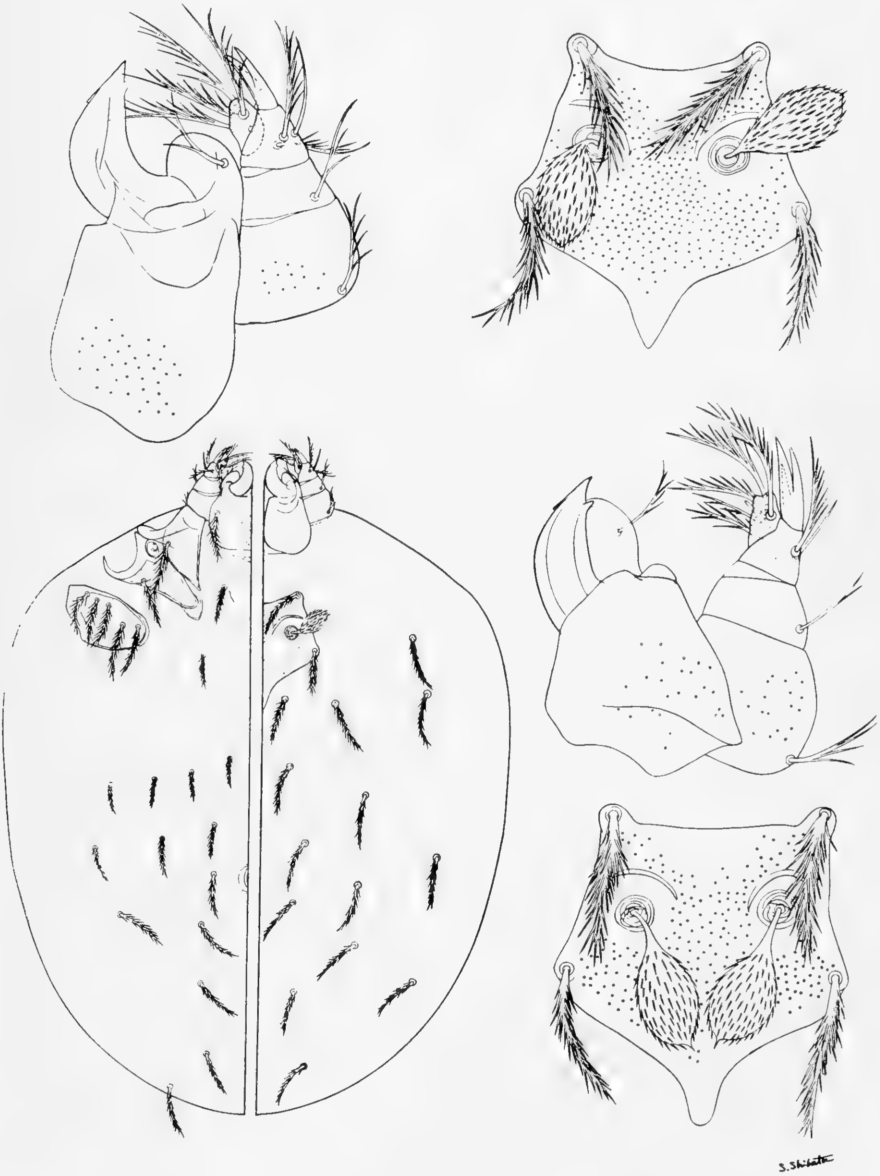


Fig. 2 *Gahrliepia ogatai*

setae between coxae III. Coxal setae 2–1–1. Scutal measurements of holotype: AW–66, PW–76.5, SB–24, ASB–27, PSB–20, SD–47.5, AP–24, AM–46, AL–46, PL–64, S–72.

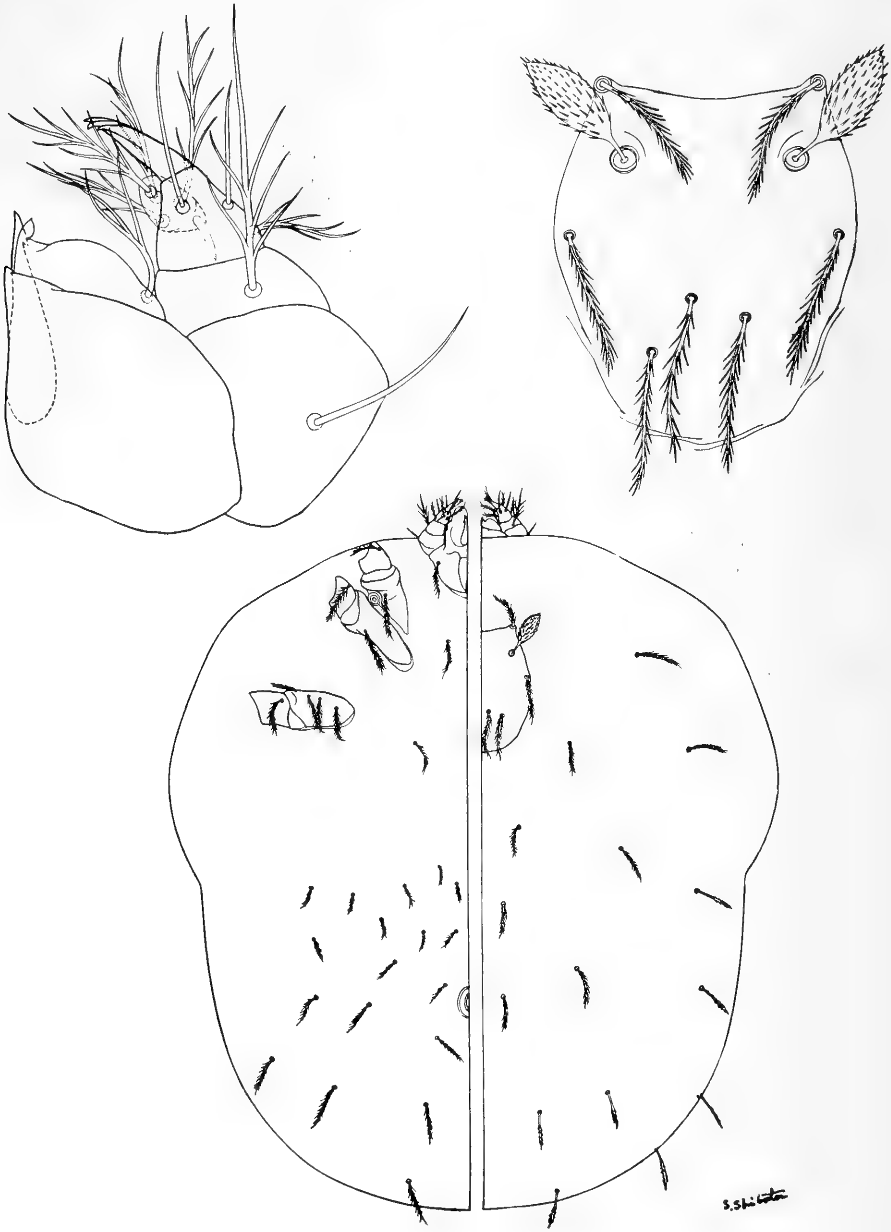


Fig. 3 *Gahrliepia saduski*

DISTRIBUTION AND HOSTS: Known only from the type collection.

TYPE DATA: From *Rattus rattus* from Miyake Island (Izu Islands, south of Tokyo), January 18, 1952; holotype and one paratype deposited at the Kitasato Institute, Tokyo.

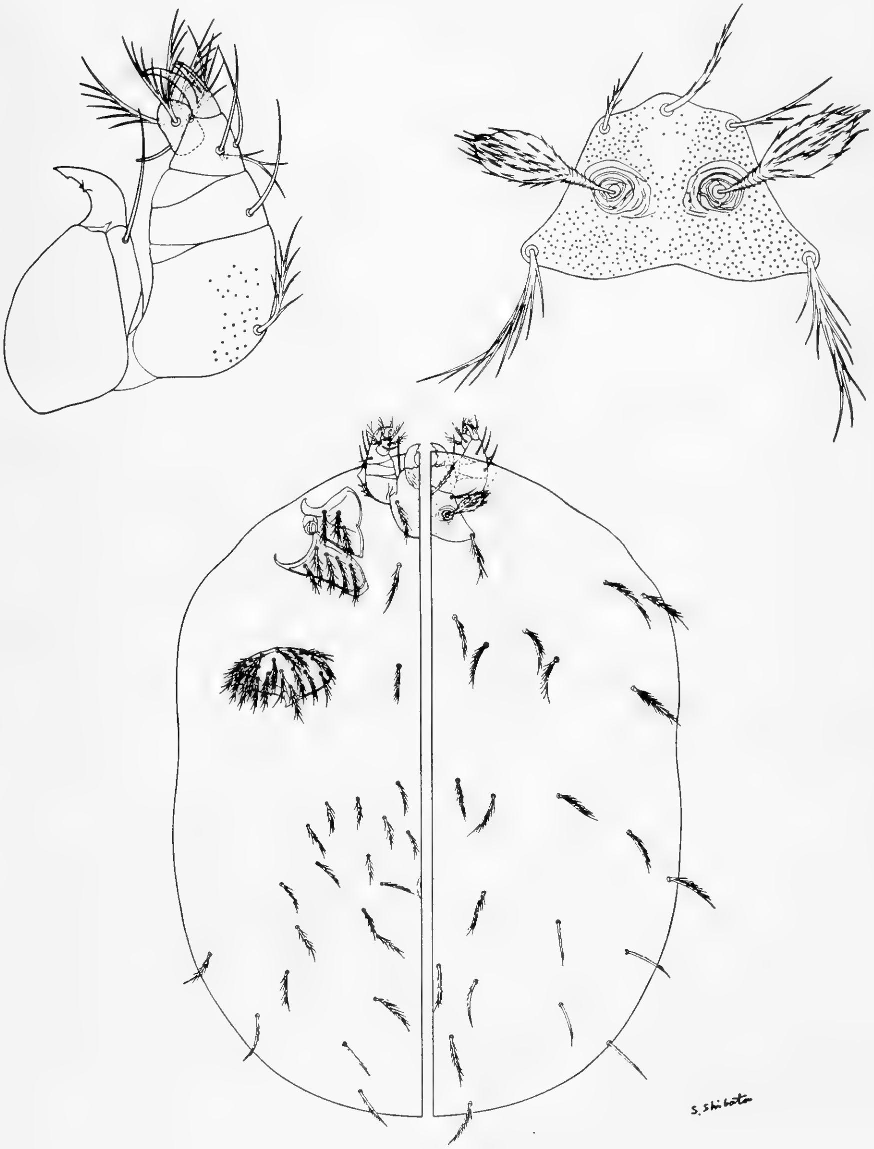


Fig. 4 *Doloisia okabei*

Gahrliepia (Walchia) ogatai (Sasa and Teramura, 1951)

(Figure 2)

Walchia ogatai Sasa and Teramura, 1951, Tokyo Iji Shinshi, vol. 68, no. 5, pp. 9–10.

Diagnosis: Galeal seta forked (not nude as in the original description); palpal setae all forked or feathered except lateral tibial seta which is nude. Scutum small, bluntly or sharply pointed posteriorly. Two pairs of humeral setae. Coxal setae 1–1–4 or 5. Sternal setae 2–2. Scutal measurements of holotype: AW–34, PW–57, SB–27, ASB–26, PSB–27, AP–36, AL–31, PL–30, S–28.

Distribution and hosts: *Mogera wogura* and *Apodemus speciosus* from Akita and Shizuoka prefectures.

Type data: Holotype and four paratypes taken from *Mogera wogura,* Uchitomo, Akita Prefecture; November 3, 1950. Deposited at the Institute for Infectious Diseases, University of Tokyo.

Gahrliepia (Gahrliepia) saduski Womersley, 1952

(Figure 3)

Gahrliepia (Gahrliepia) saduski Womersley, 1952, Records of the South Australia Museum, vol. 10, pp. 301–302.

Diagnosis: Galeal seta feathered; palpal setae feathered, except dorsal and lateral tibial setae which are nude. Scutum unsculptured and with no punctae; with 2–5 setae behind PL. Coxal setae 1–1–3, 4, or 5 (some specimens have 3 setae on coxa III on one side and 5 on the opposite side). Scutal measurements (mean of seven specimens given by the describer): AW–48.9, PW–63.5, SB–41.4, ASB–22.4, PSB–65.4, SD–87.8, AP–38.4, AL–36.7, PL–35.2, S–38.4.

Distribution and hosts: Known from many localities in Honshu, Shikoku, and Kyushu; from *Mus.* sp., *Apodemus speciosus, A. geisha, Clethrionomys smithii, Microtus montebelloi, Urotrichus talpoides,* and *Passer montanus.*

Type data: Holotype and two paratypes from *Mus.* sp., Misinobe (probably a misspelling of Mizonobe) near Yachi, Yamagata Prefecture; October 28, 1945. Holotype at South Australia Museum, Adelaide.

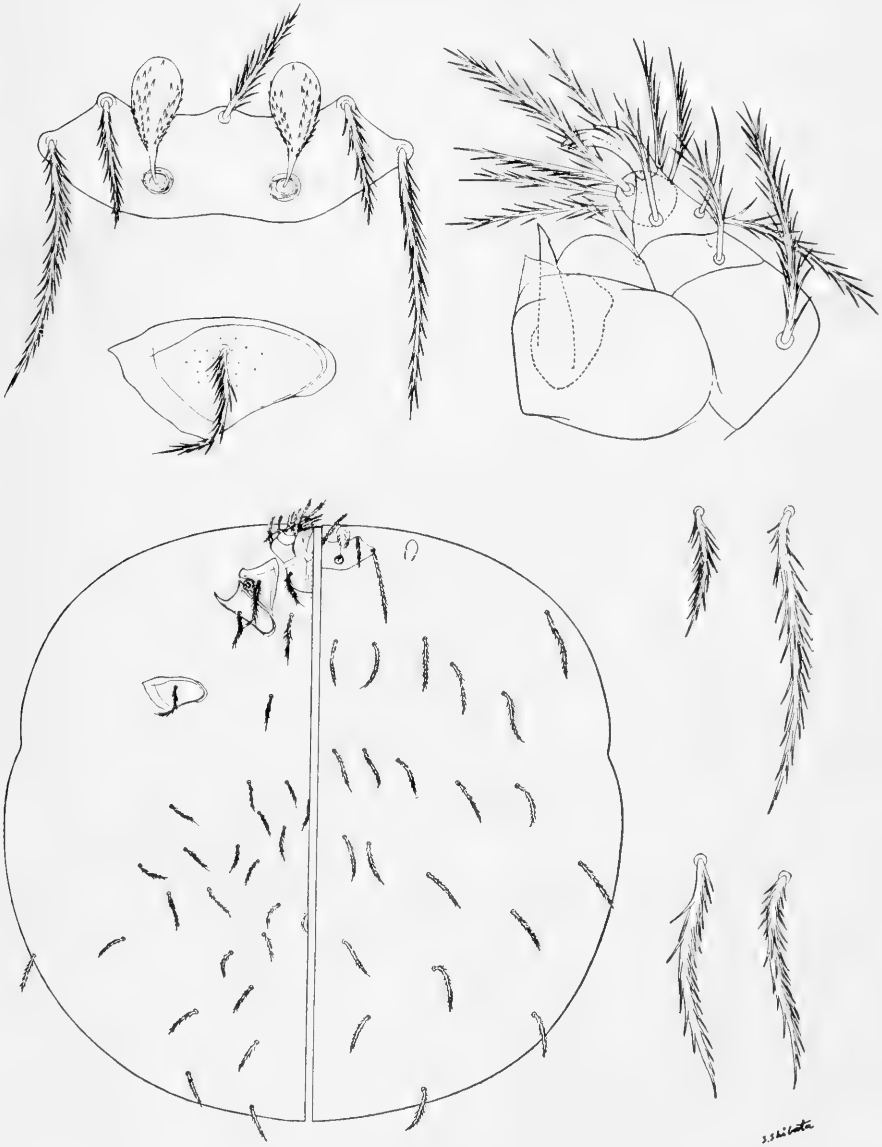
Doloisia okabei Sasa *et al.,* 1952

(Figure 4)

Doloisia okabei Sasa, Hayashi, Kawashima, Mitsutomi, and Egashira, 1952, Tokyo Iji Shinshi, vol. 69, no. 3, p. 12.

Diagnosis: The only species of the genus known from Japan. Coxal setae 2—4(4–5)—8(7–9). Sternal setae 2–2. Galeal seta nude. Palpal femoral seta feathered; palpal genual and dorsal and lateral palpal tibial setae nude; ventral tibial seta feathered. Palpal claw three-pronged. Scutal measurements of holotype: AW–28, PW–63, SB–23, ASB–23, PSB–20, AP–30, AM–30, AL–21, PL–40, S–35.

Distribution and hosts: Known only from the original collection.



S. Shibata

Fig. 5 *Euschöngastia alpina*

TYPE DATA: Holotype and two paratypes from *Urotrichus talpoides,* taken at Toshita, Kumamoto Prefecture; October 21, 1951. Holotype and two paratypes deposited at the Institute for Infectious Diseases, University of Tokyo.

Fig. 6 *Euschöngastia ikaoensis*

Genus **Euschöngastia** Ewing, 1938

Only four species of *Euschöngastia* are known from Japan and they are relatively uncommon. To date only one species *(E. ikaoensis)* is known to

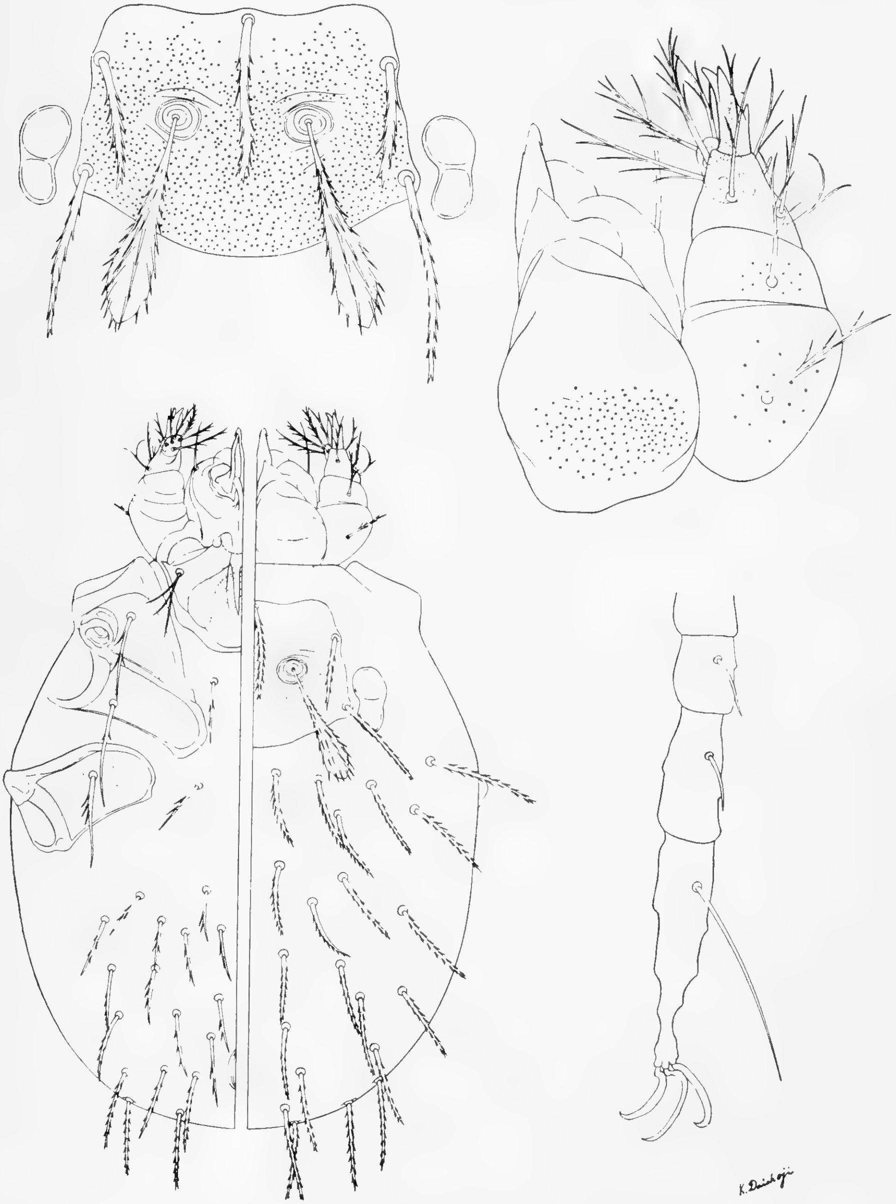


Fig. 7 *Euschöngastia kitajimai*

occur on the adjacent Asiatic mainland; this species has been taken in southern Korea. *Euschöngastia* differs from *Neoschöngastia* in the character of the scutum and in the host distribution: in *Euschöngastia* the scutum lies entirely on the surface of the integument and the hosts are mammals, whereas in *Neoschöngastia* at least some parts of the scutum lie beneath cuticular striae and the hosts are almost always birds.

Key to Japanese Species of Euschöngastia

1. No mastitarsalae III 2
— One mastitarsala III .... *E. kitajimai*

2. A single seta on coxa III 3
— Two setae on coxa III .... *E. miyagawai*

3. Two pairs of humeral setae; lateral tibial seta of palpus feathered; galeal seta nude .... *E. ikaoensis*
— A single pair of humeral setae; lateral tibial seta of palpus nude; galeal seta branched .... *E. alpina*

Euschöngastia alpina Sasa and Jameson, new species

(Figure 5)

Gnathosoma: Chelicera with a subapical dorsal tooth; cheliceral base with no punctae. Capitular sternum with a single feathered seta and a few punctae. Palpal genual and femoral setae feathered; dorsal and ventral tibial setae feathered, lateral seta nude. Palpal claw five-pronged. Galeal seta branched.

Legs: All coxae unisetose; the seta on coxa III distinctly behind the anterior margin of the coxa. Specialized (nude) setae: Leg I, 2 genulae, 1 microgenuala, 2 tibialae, 1 microtibiala, 1 spur, 1 microspur, 1 subterminala, 1 parasubterminala, 1 pretarsala; Leg II, 1 genuala, 2 tibialae, 1 spur, 1 microspur, and 1 pretarsala; Leg III, 1 genuala.

Scutum: Broadly rectangular, more than three times as wide as long, concave anteriorly, convex posteriorly, and with the lateral margins diverging posteriorly. Posterior corners angular, posterolateral setae placed in the corners. Sensillary bases behind a line connecting posterolateral setae. Sensillae pyriform. Scutum with few or no punctae. No diagonal lines in front of sensillary bases. Scutal measurements of holotype: AW–63, PW–95, SB–36, ASB–26, PSB–9, AP–20, AM–35, AL–35, PL–75, S–40.

Setae: Humeral setae similar to posterolateral setae; other dorsal setae slightly shorter. Dorsal setal formula 2–10–12–8–6–2–2. Sternal setae 2–2. About 44 small setae ventrally behind coxae III.

Type: Holotype from *Apodemus geisha*, Kamikochi (1600 meters, elevation), Nagano Prefecture; July 12, 1952. One paratype from *A. speciosus*, Mt. Hiei, Shiga Prefecture; March 27, 1952. Both specimens collected by Mitosi Tokuda and E. W. Jameson, Jr. Deposited in the United States National Museum.

Euschöngastia ikaoensis (Sasa *et al.*, 1951)

(Figure 6)

Neoschöngastia ikaoensis Sasa, Sawada, Kano, Hayashi, and Kumada, 1951, Tokyo Iji Shinshi, vol. 68, no. 4, p. 7.

Diagnosis: All palpal setae feathered. Galeal seta nude. Palpal claw 5–7 pronged. Sternal setae 2–2. Coxal setae 1–1–1. Bases of sensillae about as far from each other as from their adjacent lateral margins of the scutum; sensillae pyriform. Two pairs of humeral setae. Scutal measurements of holotype: AW–61.5, PW–67, SB–24, ASB–18, PSB–15.5, AP–21, AM–30, AL–30, PL–39, S–33.

Fig. 8 *Euschöngastia miyagawai*

Distribution and hosts: From Kanagawa, Gumma, Oita, Yamanashi, Shizuoka, Kumamoto, and Shimane prefectures from *Urotrichus talpoides, Apodemus speciosus, Clethrionomys smithii* and *Mus molossinus;* this chigger also occurs in southern Korea.

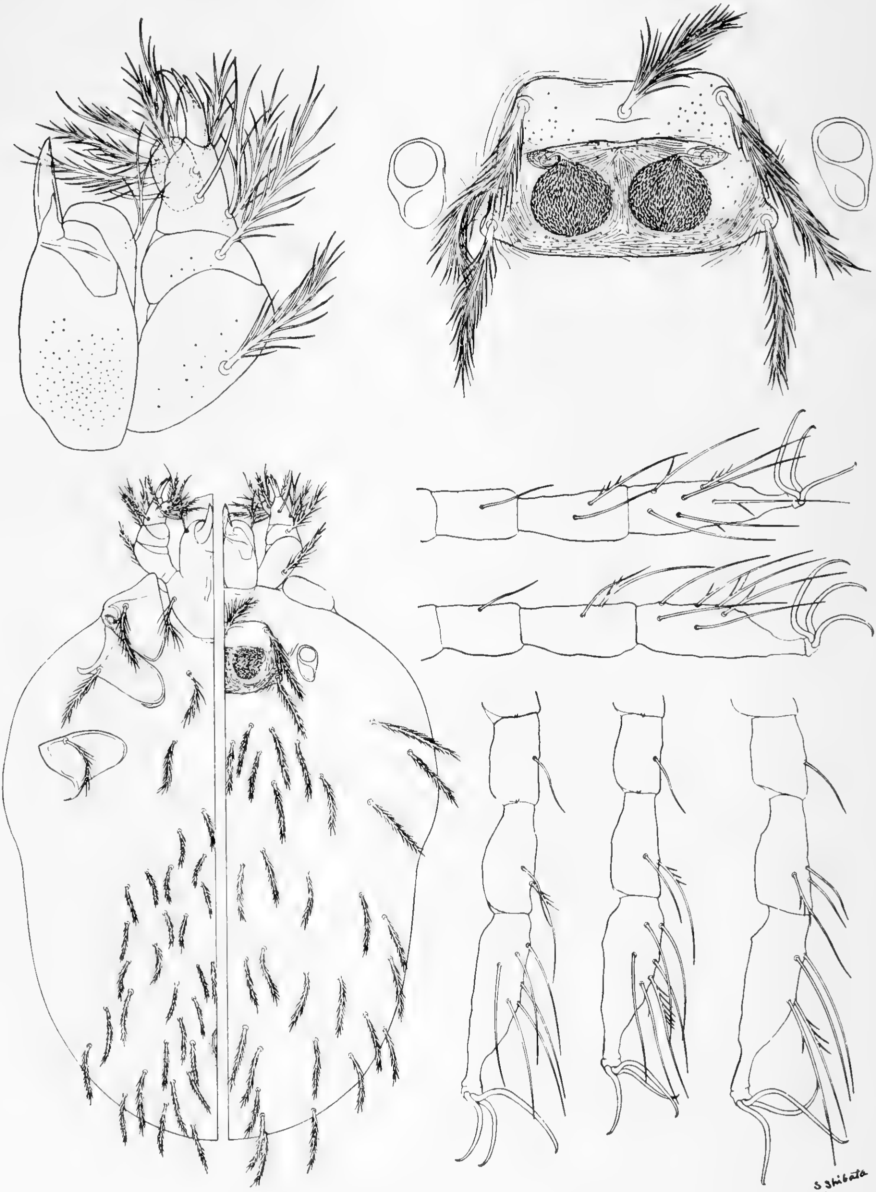


Fig. 9 *Neoschöngastia asakawai*

TYPE DATA: Holotype from *Apodemus speciosus* from Ikao, Gumma Prefecture; November 27, 1950. Two paratypes from the same host from Yamanaka, Yamanashi Prefecture; November 22, 1950. Holotype and paratypes deposited at Institute for Infectious Diseases, University of Tokyo.

Euschöngastia kitajimai Fukuzuki and Obata, 1953

(Figure 7)

Euschöngastia kitajimai FUKUZUMI and OBATA, 1953, Kitasato Archives of Experimental Medicine, vol. 26, no. 1, pp. 1–22.

DIAGNOSIS: Palpal femoral seta feathered; palpal genual seta and palpal tibial setae feathered or branched. Galeal seta nude. Palpal claw three-pronged. Sensillary bases closer to their adjacent scutal margins than to each other, midway between anterolateral and posterolateral setae. Sen-

Fig. 10 *Neoschöngastia posekanyi*

sillae about five times as long as wide, with several rows of long barbs. Sternal setae 2–2. Coxal setae 1–1–1. One mastitarsala III. Scutal measurements of holotype: AW–52, PW–62.5, SB–24, ASB–22.5, PSB–26, AP–33, AM–31, AL–25, PL–36, S–37.

DISTRIBUTION AND HOSTS: Known only from the original collection.

TYPE DATA: From *Rattus rattus*, Miyake Island (Islands of Izu, south of Tokyo); January 18, 1952; deposited at Kitasato Institute, Tokyo.

Euschöngastia miyagawai Sasa *et al.*, 1951

(Figure 8)

Euschöngastia miyagawai SASA, KUMADA, and MIURA, 1951, Tokyo Iji Shinshi, vol. 68, no. 8, p. 19.

?*Neoschöngastia covelli* RADFORD, 1953. Parasitology, vol. 42, nos. 3 and 4, pp. 233–235.

DIAGNOSIS: Palpal genual and femoral setae feathered; dorsal tibial seta branched or nude, lateral tibial seta branched, and ventral tibial seta feathered. Galeal seta nude. Palpal claw 3–5 pronged. Sensillary bases very close together; sensillae globular. Sternal setae 2–2. Coxal setae 1–1–2. Dorsal setae in indistinct rows, between 50 and 60 setae. Scutal measurements of holotype: AW–62, PW–81, SB–8, ASB–28, PSB–11, AP–26, AM–40, AL–61, PL–57, S–31.

DISTRIBUTION AND HOSTS: Known from *Apodemus speciosus* and *Mustela* sp. and several kinds of wild birds from Kanagawa, Yamanashi, and Kofu prefectures, and from Miyake Island, south of Tokyo.

TYPE DATA: Holotype and two paratypes from *Apodemus speciosus* from Okuyugawara, Kanagawa Prefecture; March 5, 1951; deposited at the Institute for Infectious Diseases, University of Tokyo.

REMARKS: The original illustration is in error in showing the seta on the first palpal segment (palpal coxal seta) nude; this seta is feathered. *Neoschöngastia covelli* Radford, 1953 closely resembles *E. miyagawai* and may well be a synonym. *N. covelli* was described from a squirrel *(Callosciurus pygerythrus)* from Imphal, Manipur State, India.

Genus **Neoschöngastia** Ewing, 1929

In Japan there are six species of *Neoschöngastia,* all parasites of birds; undoubtedly additional species will be found in the future. The condition of the palpal setae, galeal seta, number of prongs on the palpal claw, presence or absence of mastitarsalae III, number of setae on coxa III, and the number of sternal setae are all variable in this genus, and are specific characters. The almost unique feature of *Neoschöngastia* is the position of the scutum, being partly submerged beneath the integument so that the cuticular striae can be seen above the scutum.

Key to Japanese Species of Neoschöngastia

1\. Coxa III with more than a single seta 2
— Coxa III with a single seta 3
2\. Fifteen or more sternal setae .... *N. carveri*
— Two pairs of sternal setae .... *N. americana solomonis*
3\. Sternal setae 2–2–2 .... *N. paenitans*
— Sternal setae 2–2 4
4\. Sensillae spatulate, with long, slender scales .... *N. monticola*
— Sensillae globular, with short scales 5
5\. One mastitarsala III .... *N. posekanyi*
— Two to six mastitarsalae III .... *N. asakawai*

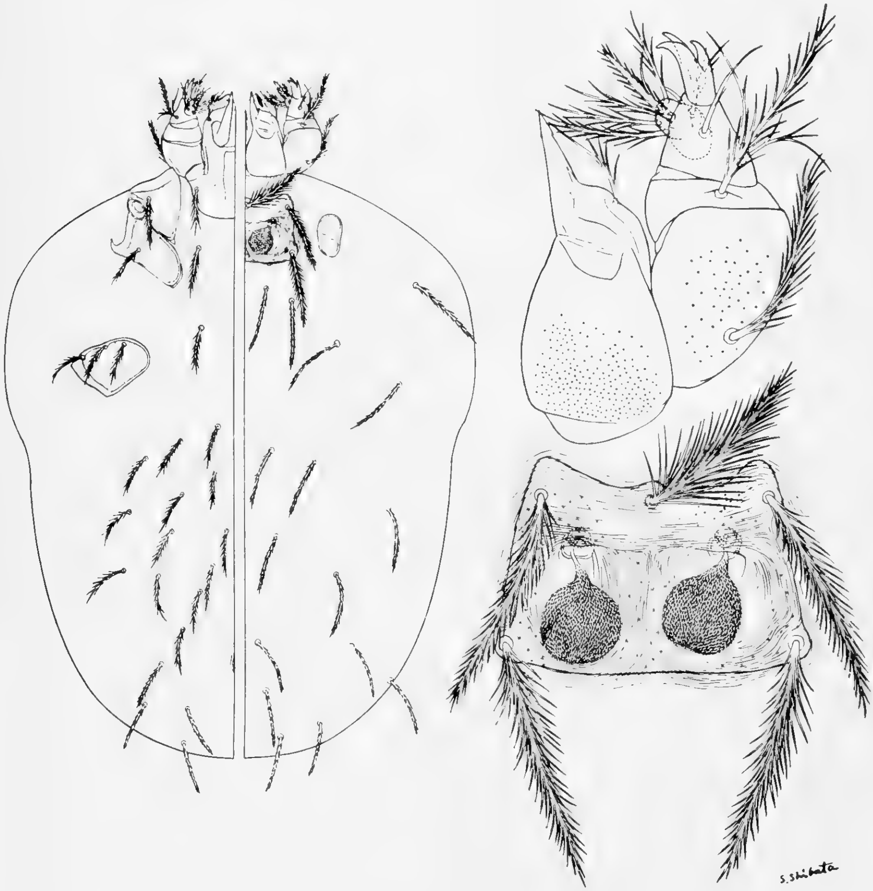


Fig. 11 *Neoschöngastia americana*

Neoschöngastia asakawai Fukuzumi and Obata, 1953

(Figure 9)

Neoschöngastia asakawai FUKUZUMI and OBATA, 1953, Kitasato Archives of Experimental Medicine, vol. 26, no. 1, pp. 1–22.

DIAGNOSIS: This species bears some resemblance to *N. posekanyi,* but is distinguished by the greater number of mastitarsalae III and two or three pairs of humeral setae. In *N. asakawai* there are many more dorsal setae than in *N. posekanyi.* The variation in the number of mastitarsalae III (Fig. 9) is quite uncommon in *Neoschöngastia;* these nude setae numbered from two to six. Scutal measurements of holotype: AW–50, PW–68, SB–41.5, ASB–22.5, PSB–30, SD–50.5, AP–40, AM–41.5, AL–51, PL–46, S–26.5.

DISTRIBUTION AND HOSTS: Collected from birds *(Scolopax rusticola, Bambusicola thoracica, Siphia mugimaki, Prunella rubida, Emberiza cliodes,*

Fig. 12 *Neoschöngastia paenitens*

E. spodecephala, Turdus obscurus, and *Passer montanus)*; known from Miyake Island (Tokyo-to) and Yamanashi Prefecture.

Type data: Holotype from *Scolopax rusticola,* Miyake Island (Islands of Izu, south of Tokyo); January 20, 1952; deposited at Kitasato Institute, Tokyo.

Fig. 13 *Neoschöngastia carveri*

Neoschöngastia posekanyi Wharton and Hardcastle, 1946

(Figure 10)

Neoschöngastia posekanyi Wharton and Hardcastle, 1946, Journal of Parasitology, vol. 32, p. 302.

Diagnosis: Head of sensillae globular, with small scales. Coxae unisetose. Sternal setae 2–2. One mastitarsala III. One pair of humeral setae. Galeal seta nude (in original description) or 2–3 forked (in Japanese specimens). Palpal femoral and genual setae branched; dorsal tibial seta nude; lateral tibial seta forked; and ventral tibial seta feathered. Scutal measurements (mean of five specimens) given by the describers: "AW–75, PW–80, SB–47, ASB–25, PSB–34, AP–29, AM–49, AL–73, PL–52, S–30."

Distribution and hosts: Collected from birds *(Turdus celaenops, Monticola solitarius, Streptopelia orientalis,* and *Columba janthina)* from Hachijo and Koshima islands, south of Tokyo; *Saxicola torquata* and *Chloris sinica,* Schizuoka Prefecture.

Type data: Holotype from *Streptopelia orientalis,* Hianza Island, Okinawa. Deposited in the United States National Museum.

Neoschöngastia americana solomonis Wharton and Hardcastle, 1946

(Figure 11)

Neoschöngastia americana solomonis Wharton and Hardcastle, 1946, Journal of Parasitology, vol. 32, p. 289.

Diagnosis: Coxal setae 1–1–3. No mastitarsalae III. Sternal setae 1–1. One pair of humeral setae. Galeal seta branched, and all palpal setae branched or feathered. Palpal claw three-pronged. Sensillary bases far apart; nearer their adjacent scutal margina than to each other. Sensillae globular, with many fine scales. Scutal measurements (mean of five specimens from Okinawa) as given by the describers: "AW–51, PW–70, SB–37, ASB–25, PSB–30, AP–36, AM–44, AL–56, PL–59, S–24." Scutal measurements of a specimen from Japan: AW–50, PW–64, SB–34, ASB–34 PSB–31, AP–36, AM–42, AL–55, PL–52, S–25.

Distribution and hosts: From Hachijo Island from *Monticola solitarius.* Originally described from Bougainville, Guam, and Okinawa. *Neoschöngastia a. americana* is known from North America.

Type data: Collected from *Hirundo tahitica,* Cape Torokina, Bougainville; July 3, 1944. Holotype deposited in the United States National Museum.

Remarks: In scutal measurements the Japanese specimens resemble *N. a. solomonis* more closely than *N. a. americana,* but the difference (length of the scutum) may well prove to be clinal.

Fig. 14 *Neoschöngastia monticola*

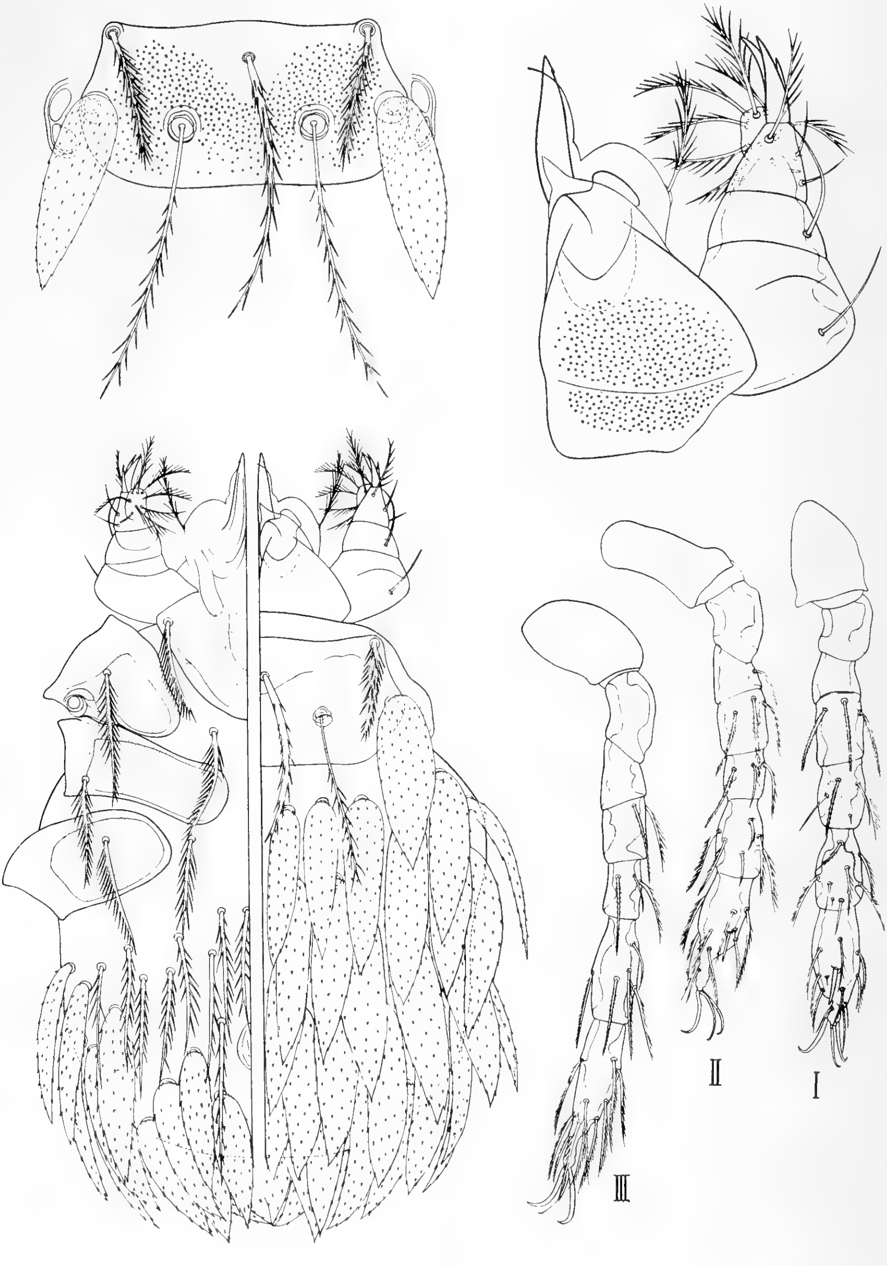


Fig. 15 *Trombicula kansai*

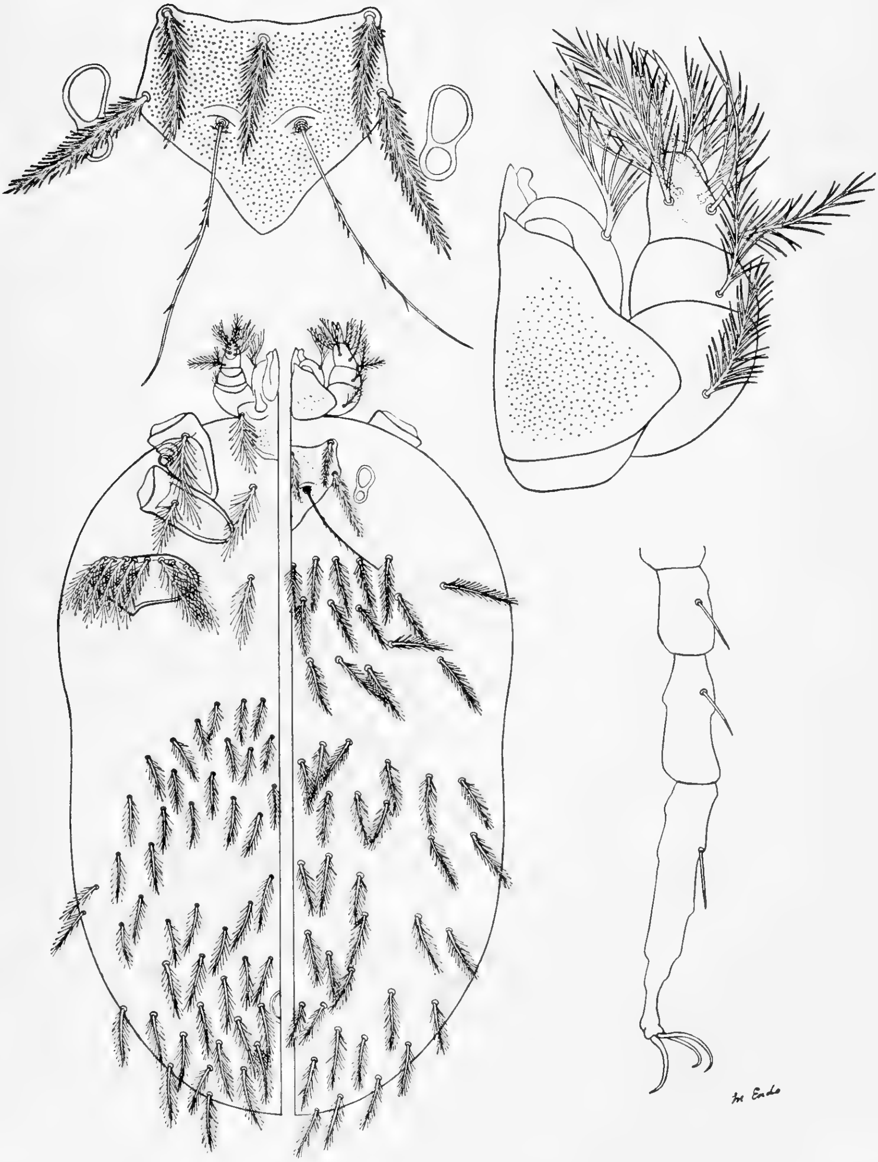


Fig. 16 *Trombicula kochiensis*

Neoschöngastia paenitens Brennan, 1952

(Figure 12)

Neoschöngastia kohlsi BRENNAN, 1951, Journal of Parasitology, vol. 37, no. 579; preoccupied by *N. kohlsi* Philip and Woodward, 1946.

N. paenitens BRENNAN, 1952, Proceedings Entomological Society of Washington, vol. 54, p. 137.

?*N. okumurai* FUKUZUMI and OBATA, 1953, Kitasato Archives Experimental Medicine, vol. 26, no. 1, pp. 1–22.

DIAGNOSIS: Coxal seta 1–1–1. Two almost nude setae on tarsus III. Femoral, genual, and ventral tibial setae of palpus branched or feathered. Lateral and dorsal tibial setae of palpus nude. Galeal seta nude. Sensillary bases closer to each other than to their respective scutal margins; sensillae globular, with many fine scales. Scutal measurements of holotype (Brennan, 1951: 580): "AW–52, PW–76, SB–25, ASB–25, PSB–20, AP–38, AM–40, AL–54, PL–49, S–31." Scutal measurements of a Japanese specimen: AW–49, PW–71, SB–21, ASB–25, PSB–18, AP–32, AM–31, AL–50, PL–53, S–28.

DISTRIBUTION AND HOSTS: Previously known only from Montana, U.S.A. In Japan known from Aomori Prefecture and Hachijo Island from *Monticola solitarius.*

TYPE DATA: Collected from *Petrochelidon pyrrhonota,* Granite County, Montana; July 17, 1950. Holotype deposited in the United States National Museum.

COMMENT: *N. okumurai* Fukuzumi and Obata seems closely related to *paenitens* and is probably a synonym.

Neoschöngastia carveri Wharton and Hardcastle, 1946

(Figure 13)

Neoschöngastia carveri WHARTON and HARDCASTLE, 1946, Journal of Parasitology, vol. 32, p. 313.

DIAGNOSIS: This species is distinct in the large number of sternal setae (20–24), the numerous setae on coxa III (5–8), the excessively long spur on leg I (more than half as long as the tarsus), and the presence of at least two genualae on each leg. Scutal measurements (mean of five specimens) as given by the describers: "AW–80, PW–84, SB–43, ASB–30, PSB–37, AP–45, AM–71, AL–74, PL–141, S–40." Scutal measurements of a Japanese specimen: AW–83, PW–84, SB–36, ASB–31, PSB–38, AP–46, AM–46, AL–76, PL–120, S–42.

DISTRIBUTION AND HOSTS: Originally described from Guam, Okinawa, Ulithi and Peleliu from numerous birds; in Japan from *Monticola solitarius* from Hachijo Island.

Type data: Collected from *Demigretta sacra,* Port Ajayan, Guam; July 16, 1945. Deposited in the United States National Museum.

Fig. 17 *Trombicula japonica*

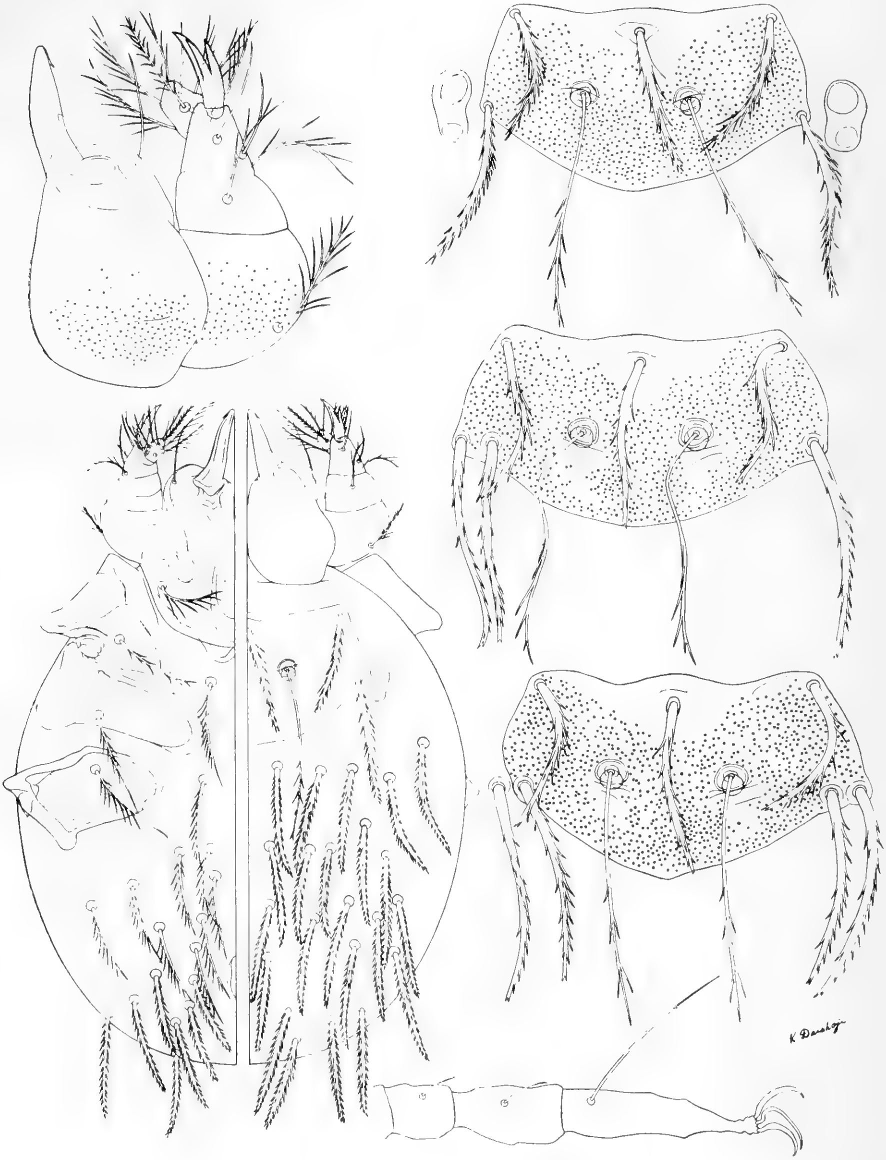


Fig. 18 *Trombicula nagayoi*

Neoschöngastia monticola Wharton and Hardcastle, 1946
(Figure 14)

Neoschöngastia monticola Wharton and Hardcastle, 1946, Journal of Parasitology, vol. 32, p. 301.

Diagnosis: Distinctive in the narrow sensillae which are provided with long hairs. Coxae unisetose. Sternal setae 2–2. One mastitarsala III. One pair of humeral setae. Scutal measurements (mean of five specimens)

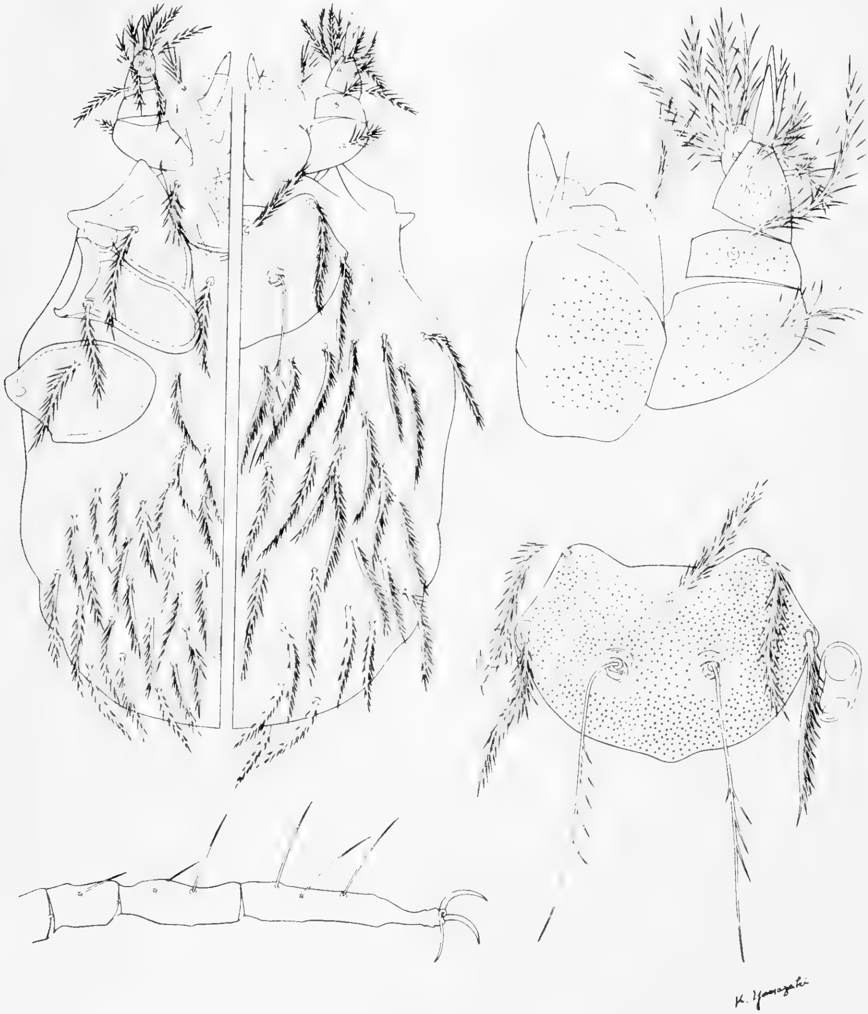


Fig. 19 *Trombicula mitamurai*

given by the describers: "AW–56, PW–78, SB–32, ASB–24, PSB–26, AP–27, AM–43, AL–35, PL–75, S–71." Scutal measurements of a Japanese specimen: AW–57, PW–83, SB–34, ASB–25, PSB–28, AP–29, AM–43, PL–36, PL–76, S–70.

DISTRIBUTION AND HOSTS: Originally known only from Okinawa. As stated by the describers, this chigger seems to be confined to birds of the genus *Monticola*. In Japan it occurs on *Monticola solitarius* on Miyake Island and Hachijo Island.

TYPE DATA: From *Monticola solitarius,* Takabannase Island, Okinawa; June 10, 1945. Holotype in the United States National Museum.

Genus **Trombicula** Berlese, 1905

The genus *Trombicula* is based on adult morphology; the larva of the genotype (*Trombicula minor* Berlese) has not yet been associated with the adult, and therefore the current definition of the larval stage of *Trombicula* is tentative, a clarification pending the discovery of the larva of *Trombicula minor.* This interesting situation has been discussed at length by various authors. In *Trombicula* we include those chiggers with seven segments in each leg, the scutum with five setae and a pair of flagelliform sensillae, and in which the empodium is claw-like. There are several subgenera and numerous species that do not fit into any established subgenera.

Subgenus **Trombiculindus** Radford, 1948

Trombiculindus was established as a genus for a chigger in which the posterolateral setae and some of the body setae are expanded and foliate. This is the only distinctive feature of this group, and we consider it as a subgenus in this paper. One species is known from Japan; the other species of *Trombiculindus* are recorded from the tropical Orient.

Trombicula (Trombiculindus) kansai Jameson and Sasa, 1953

(Figure 15)

Trombicula (Trombiculindus) kansai JAMESON and SASA, 1953, Journal of Parasitology, vol. 39, pp. 247–249.

DIAGNOSIS: With the foliate posterolateral setae characteristic of the subgenus. Palpal genual, femoral, and lateral and ventral tibial setae nude; dorsal tibial seta feathered. Galeal seta feathered. Sensillary bases slightly behind posterolateral setae; sensillae nude basally, with barbs on the distal two-thirds. Posterolateral setae with small barbs on their surface. Sternal setae 2–2. Coxal setae 1–1–1. Two pairs of humeral setae. All dorsal setae and approximately half of the ventral setae foliate. Scutal measurements of holotype: AW–70, PW–82, SB–33, ASB–29, PSB–17, AP–20, AM–79, AL–44, PL–58, S–64.

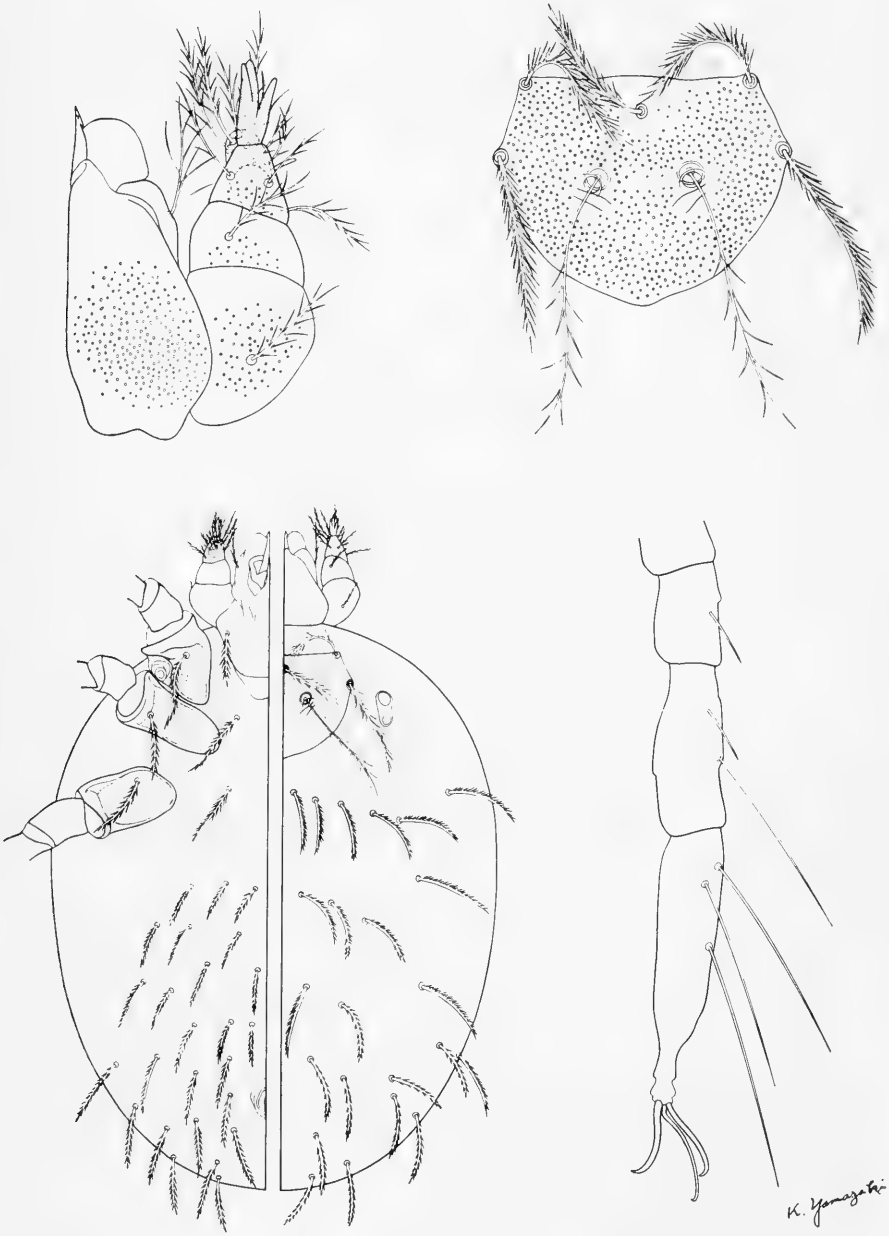


Fig. 20 *Trombicula tamiyai*

DISTRIBUTION AND HOSTS: Most of the specimens were collected from the shrew-mole, *Urotrichus talpoides;* they usually attached at the base of the tail. A few specimens were found on the mice, *Apodemus geisha* and *A. speciosus.* Kyoto, Hyogo, Mie, Shiga, Kumamoto, and Oita prefectures.

TYPE DATA: Holotype from *Urotrichus talpoides,* Ohara Area (near Kyoto City), Kyoto Prefecture; March 8, 1952. Holotype and ten paratypes deposited in the United States National Museum.

Subgenus **Miyatrombicula** Sasa, Kawashima, and Egashira, 1952.

This monotypic subgenus is characterized by the multisetal condition of coxa III, the pentagonal scutum, and the presence of a short mastitarsala III. It appears to be allied to *Trombicula cynos* Ewing of North America, and a comparison of these two species should be made.

Trombicula (Miyatrombicula) kochiensis Sasa *et al.*, 1952

(Figure 16)

Trombicula (Miyatrombicula) kochiensis SASA, KAWASHIMA, and EGASHIRA, 1952, Tokyo Iji Shinshi, vol. 27, no. 6, p. 5.

DIAGNOSIS: All palpal setae feathered. Palpal claw three-pronged. Galeal seta feathered. Scutum pentagonal, posterior margin projected and rather pointed. Sensillary bases slightly behind a line connecting postero-lateral setae. Bases of sensillae nude; distal half or two-thirds with short barbs. Scutal setae densely plumose. Dorsal setae 80 or more, in poorly defined rows. Sternal setae 2–2. Coxal setae 1–1–6(6–9). One very short mastitarsala III. Scutal measurements of holotype: AW–63.5, PW–76, SB–26.5, ASB–38, PSB–35, SD–73, AP–28, AM–40.5, AL–47.5, PL–58.5, S–84.

DISTRIBUTION AND HOSTS: Kochi, Tottori, Shimane, Kumamoto, Oita and Hyogo prefectures from *Apodemus speciosus, Clethrionomys smithii* and *Rattus norvegicus.*

TYPE DATA: From *Rattus norvegicus,* Kochi City Park, Kochi Prefecture; November 14, 1951; collected by F. Kawashima; deposited at the Institute for Infectious Diseases.

Subgenus **Neotrombicula** Hirst, 1925

This group of species is easily recognized by several morphological characters: scutum more or less pentagonal with the posterior margin broadly projected (rounded or bluntly pointed), leg III with at least one mastitarsala, unisetose coxae, and sternal setae 2–2; the palpal claw is three-pronged, and the lateral prong is usually conspicuously divergent. Brennan and Wharton (1950) recently discussed the North American species of *Neotrombicula*, and separated them into several groups: the "*autumnalis*", "*bisignata*", and "*microti*" groups of Brennan and Wharton are

Fig. 21 *Trombicula microti*

all represented in Japan. They are parasitic on a variety of small mammals and seem to have no well developed host specificities. Of the six species of the subgenus *Neotrombicula* known from Japan, five (*T. (N.) tamiyai, T. (N.) pomeranzevi, T. (N.) microti, T. (N.) nagayoi,* and *T. (N.) japonica*) also occur on the adjacent Asiatic mainland, and two (*T. (N.) pomeranzevi* and *T. (N.) microti*) are known to occur in North America.

Key to Japanese Species of Neotrombicula

1\. One mastitarsala III ("*autumnalis*" group) 2
— One mastitibiala III and two or three mastitarsalae III 3
2\. Sensillary bases in advance of posterolateral setae; usually one pair of humeral setae .... *T. (N.) nagayoi*
— Sensillary bases on a line with posterolateral setae; usually two pairs of humeral setae .... *T. (N.) japonica*
3\. One mastifemorala III, one mastitibiala III, and two mastitarsalae III ("*microti*" group) 4
— No mastifemorala III, one mastitibiala III, and three mastitarsalae III ("*bisignata*" group) 5
4\. More than 50 dorsal setae; palpal genual and femoral setae feathered .... *T. (N.) pomeranzevi*
— Fewer than 30 dorsal setae; palpal genual and femoral setae nude .... *T. (N.) microti*
5\. Sensillae branched on middle third only; coxa III oval .... *T. (N.) mitamurai*
— Sensillae branched on distal two-thirds; coxa III elongate .... *T. (N.) tamiyai*

Trombicula (Neotrombicula) japonica Tanaka *et al.*, 1930

(Figure 17)

Trombicula autumnalis japonica Tanaka, Kaiwa, Teramura, and Kagaya, 1930, Zentralblatt Bakteriologie, Abt. 1, Band 116, p. 353.

Diagnosis: Galeal seta usually nude, sometimes forked. Palpal femoral, genual, and ventral tibial setae feathered; lateral tibial seta forked or nude; dorsal tibial seta nude. Basal third of sensillae nude; distal two-thirds with moderate branches. Sensillary bases approximately on a line with posterolateral setae. Usually two pairs of humeral setae. Dorsal setae rather long, with short barbs. Scutal measurements of a topotype: AW–81.5, PW–100, SB–34, ASB–37.5, PSB–24, AP–31, AM–70, AP–67.5, PL–82.5, S–80.0 (sensillae measured on a different, but topotypical specimen).

Distribution and hosts: Known from Akita, Niigata, Yamagata, Yamanashi, Ishikari, Nagano, Kyoto, Kumamoto, and Oita prefectures; collected from *Apodemus geisha A. speciosus, Clethrionomys rufocanus,* and *Microtus montebelloi.* Known also from southern Korea.

Type data: Described from *Microtus montebelloi* (?) taken at Yuzawa, Akita Prefecture.

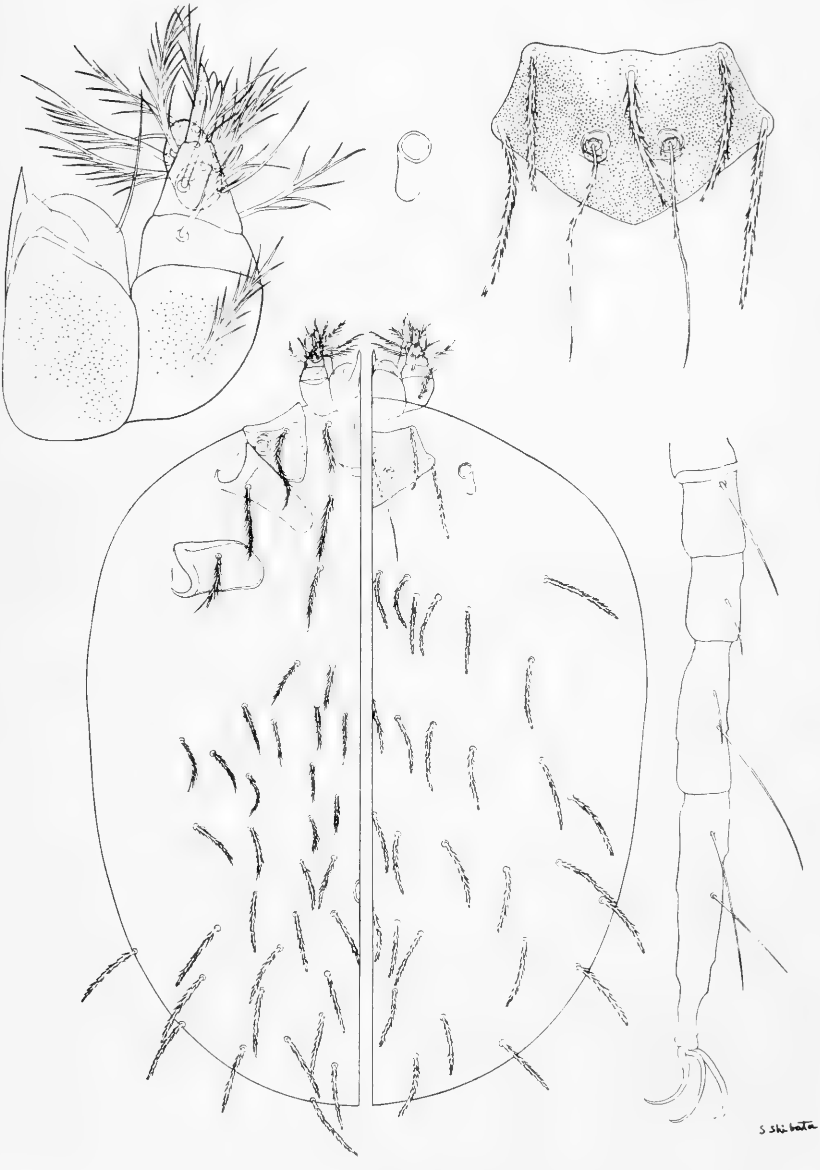


Fig. 22 *Trombicula pomeranzevi*

Trombicula (Neotrombicula) nagayoi Sasa *et al.,* 1950

(Figure 18)

Trombicula nagayoi SASA, HAYASHI, SATO, MIURA, and ASAHINA, 1950, Tokyo Iji Shinshi, vol. 67, no. 12, p. 14.

DIAGNOSIS: The gnathosomal features of *T. nagayoi* are similar to those of *T. japonica,* but generally there are fewer branches on the setae. Palpal femoral seta feathered; palpal genual seta and ventral tibial seta branched; dorsal and lateral tibial setae nude. Galeal seta nude. Sensillary bases distinctly forward of the posterolateral setae. One pair of humeral setae. Dorsal setae shorter than in *T. japonica* and with more barbs. Of the three scuta illustrated (fig. 18), the uppermost is from a paratype slide; the lower two scuta were from a collection in which the scuta were slightly larger and in 12 of 24 specimens bore supernumerary scutal setae. Such aberrations are not infrequent and *T. nagayoi* is especially variable in this respect. Scutal measurements of holotype: AW–72, PW–89, SB–30, ASB–27, PSB–29, AP–31, AM–45, AL–41, PL–57, S–75.

DISTRIBUTION AND HOSTS: Yamanashi, Iburi, Kyoto, and Eniwa prefectures from *Apodemus speciosus, Clethrionomys rufocanus,* and *Microtus montebelloi.* Known also from southern Korea.

TYPE DATA: From *Apodemus speciosus,* Yamanaka, Yamanashi Prefecture. Deposited at Institute for Infectious Diseases, University of Tokyo.

Trombicula (Neotrombicula) mitamurai Sasa *et al.,* 1950

(Figure 19)

Trombicula mitamurai SASA, HAYASHI, KUMADA, and TERAMURA, 1950, Tokyo Iji Shinshi, vol. 67, no. 11, p. 18.

DIAGNOSIS: All palpal setae branched or feathered. Galeal seta feathered. Cheliceral base and segments of palpi dorsally with small punctae. Sensillary bases behind posterolateral setae. Sensillae nude basally and distally, with 4–6 branches along middle third. With one or two pairs of humeral setae. Coxa II shaped as illustrated, distinctly more oval than that of *T. tamiyai.* Scutal measurements of holotype: AW–59, PW–84.5, SB–26, ASB–31, PSB–29, AP–26, AM–48, AL–54.5, PL–58, S–81.

DISTRIBUTION AND HOSTS: This species is known from Kanagawa, Shizuoka, Oita, and Yamanashi prefectures from *Urotrichus talpoides, Apodemus speciosus,* and *Microtus montebelloi.*

TYPE DATA: Holotype and one paratype from *Urotrichus talpoides* at Yamanaka (slope of Mt. Fuji), Yamanashi Prefecture; deposited at the Institute for Infectious Diseases, University of Tokyo.

Trombicula (Neotrombicula) tamiyai Philip and Fuller, 1950

(Figure 20)

Trombicula tamiyai Philip and Fuller, 1950, Parasitology, vol. 40, p. 51.

Diagnosis: Generally quite similar to *T. mitamurai* Sasa *et al.*, but with the distal half or two-thirds of the sensillae with eight or more branches.

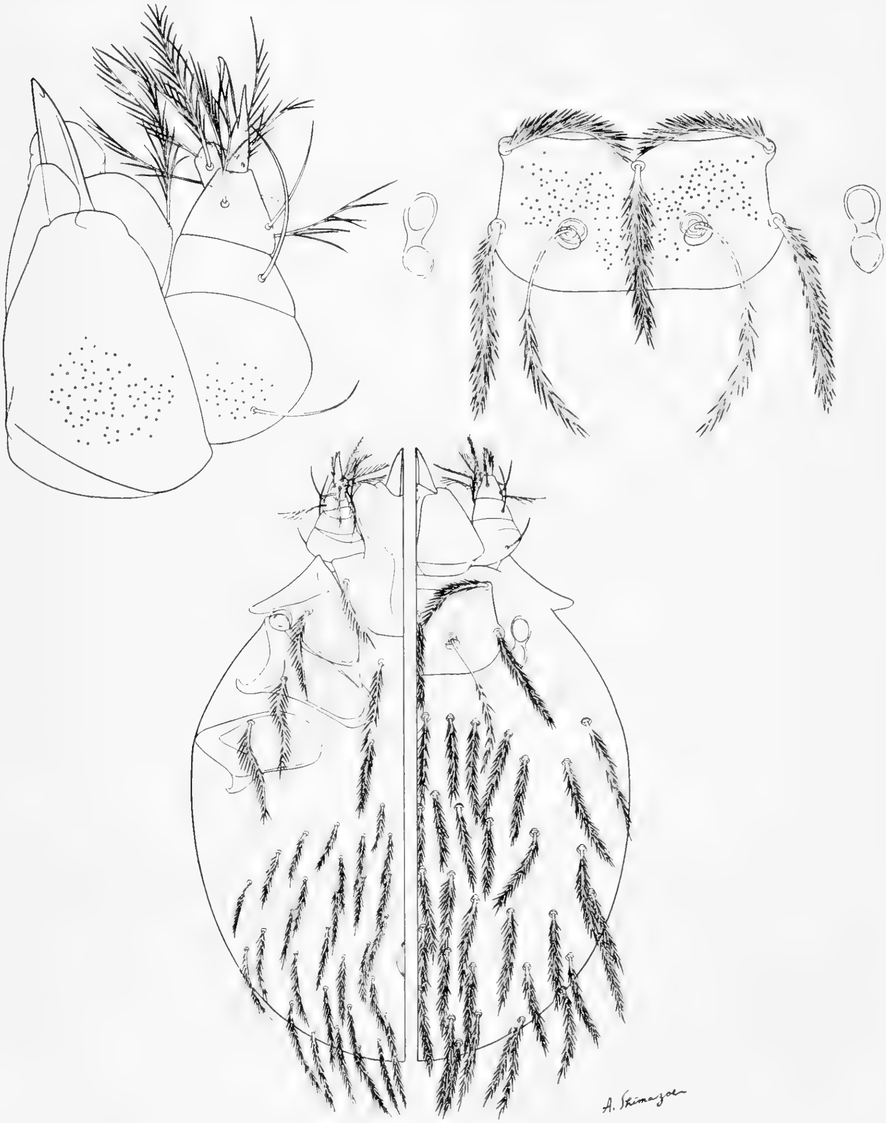


Fig. 23 *Trombicula palpalis*

Coxa III more elongate than in *T. mitamurai.* Scutal measurements of type series as given by describers: "AW–65.5, PW–80, SB–25.6, ASB–28.8, PSB–30, AP–19.2, AM–48, AL–42.5, PL–60.8, S–73.6."

DISTRIBUTION AND HOSTS: Yamagata, Niigata, and Akita prefectures; from *Microtus montebelloi.* Known also from southern Korea, from a variety of small rodent hosts.

TYPE DATA: Holotype from *Microtus montebelloi* from Okiage Village, Yamagata Prefecture; September 17, 1920. Type in the United States National Museum.

Trombicula (Neotrombicula) microti Ewing, 1928

(Figure 21)

Trombicula microti EWING, 1928, Proceedings of the Entomological Society of Washington, vol. 30, pp. 77–80.

DIAGNOSIS: Similar in some respects to *T. pomeranzevi* Schluger, especially in the vestiture of the legs. Palpal genual and femoral setae nude; dorsal seta on palpal tibia branched, lateral seta nude, and ventral seta branched. Galeal seta branched or feathered. Sensillary bases slightly in front of posterolateral setae; sensillae with scattered barbs along most of their lengths. Twenty-four to twenty-six dorsal setae in Japanese specimens. Scutal measurements of a specimen from Honshu: AW–47, PW–90, SB–28, ASB–33, PSB–28, AP–32, AM–46, AL–52, PL–56, S–84. Japanese specimens differ from North American specimens chiefly in the distribution of barbs along the sensillae.

DISTRIBUTION AND HOSTS: In Japan this species has been collected from Aomori Prefecture on Honshu and Daisetsu, Hokkaido. Known from many kinds of small rodents and insectivores from many localities in the United States and Canada. Dr. Kiyoshi Asanuma has collected this species from eastern Manchuria.

TYPE DATA: Type from *Microtus richardsoni,* Lincoln County, Wyoming, U. S. A.; August 13, 1927; deposited in the United States National Museum.

Trombicula (Neotrombicula) pomeranzevi Schluger, 1948

(Figure 22)

Trombicula pomeranzevi SCHLUGER, 1948, Entomologicheskoe Obozrenie, (Moscow), tome 30, p. 157.

Trombicula alaskensis BRENNAN and WHARTON, 1950, American Midland Naturalist, vol. 45, p. 178, *new synonymy.*

Diagnosis: All palpal setae (except ventral tibial seta) feathered; galeal seta nude. Sensillary bases slightly behind posterolateral setae. Sensillae with minute barbs on the basal half. Fifty or more dorsal setae. There appear to be no characters by which *T. alaskensis* can be separated

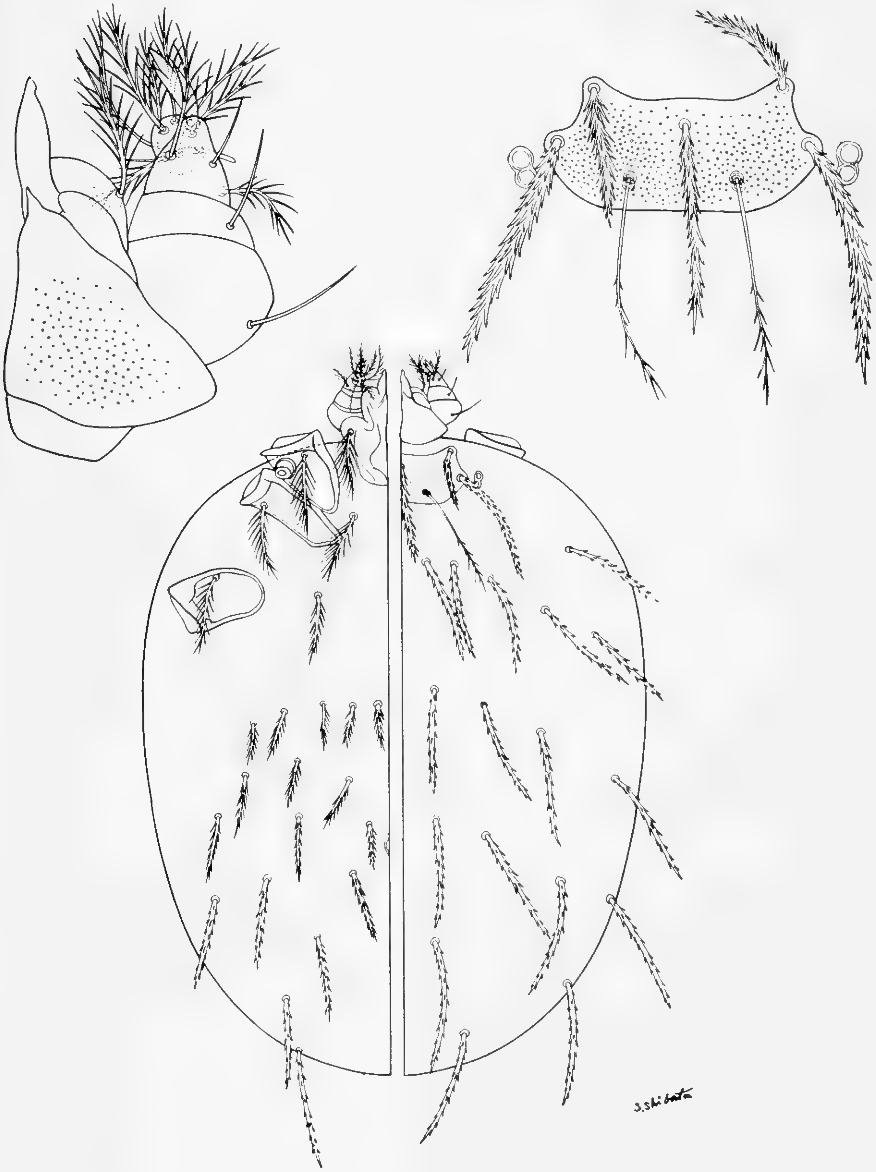


Fig. 24 *Trombicula yasuokai*

from *T. pomeranzevi.* North American specimens of *T. alaskensis* were compared with *T. pomeranzevi* from Hokkaido, and there are no differences of specific merit. Dr. Brennan examined some of the Japanese specimens of *T. pomeranzevi* and concurred with our opinion. Scutal measurements

Fig. 25 *Trombicula himizu*

of a specimen from Hokkaido: AW–85.0, PW–112.5, SB–32.5, ASB–42.5, PSB–32.5, AP–36, AM–62.5, AL–65, PL–75, S–112.5.

Distribution and hosts: Known from *Clethrionomys rutilis* and *Apodemus speciosus* from Aomori and Ishikari prefectures. Known also from U.S.S.R. and North America.

Type data: Described from *Clethrionomys rufocanus* and *Apodemus speciosus* from South Shore, vicinity of Barrabasha, U.S.S.R.; June 19, August 5, and September 24, 1940.

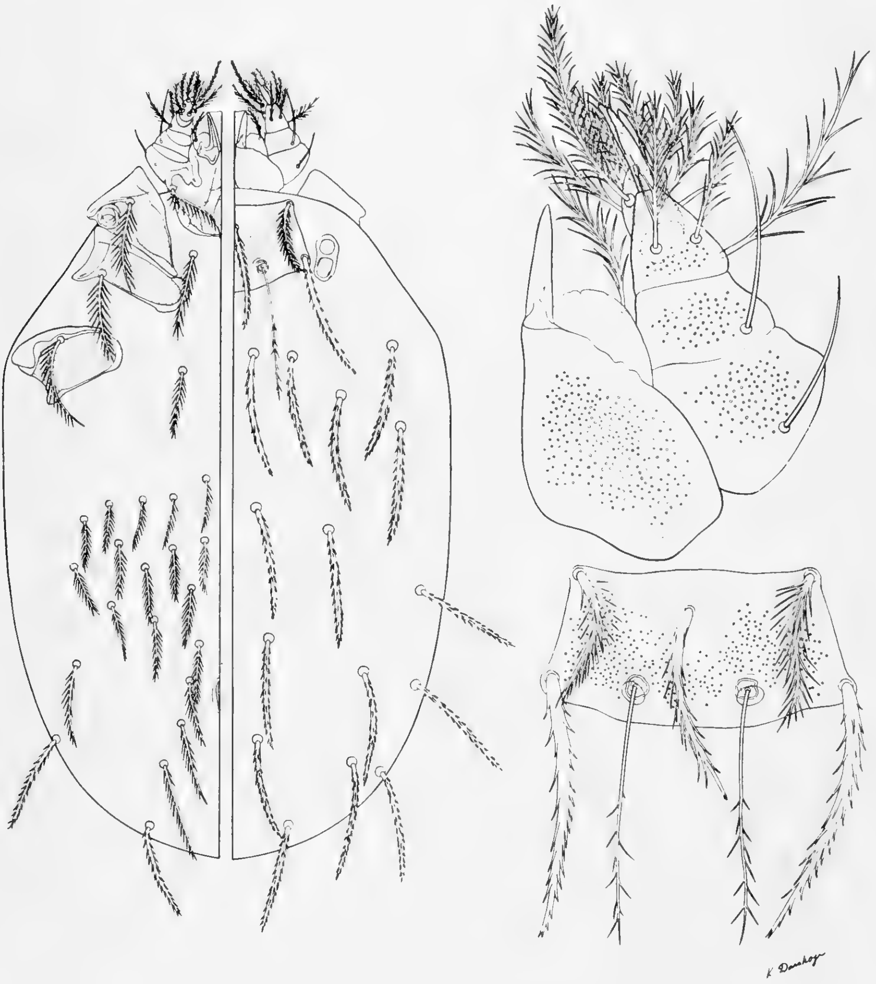


Fig. 26 *Trombicula miyajimai*

Subgenus **Leptotrombidium** Nagayo *et al.*, 1916

In *Leptotrombidium* the palpal femoral and genual setae are nude; the palpal claw is three-pronged (the prongs being closely appressed); the galeal seta is feathered; the scutum more or less rectangular; the sternal setae 2–2; the coxal setae 1–1–1; and there are no mastitarsalae III. Important specific characters in this group are the shape of the scutum, position of sensillary bases, character of the sensillae and scutal setae, number and character of dorsal body setae, and the position of the seta on coxa III.

There are 18 species of *Leptotrombidium* in Japan, a rather large concentration of forms: this figure does not include several probable synonyms; and, as there are doubtless others to be discovered, our list is conservative. Only four of these species (*T. palpalis, T. akamushi, T. pallida,* and *T. fuji*) are known to occur outside of Japan. The species of *Leptotrombidium* are usually common within their geographic range: *T. (L.) fuji, T. (L.) kitasatoi, T. (L.) palpalis, T. (L.) intermedia,* and *T. (L.) scutellaris* have a rather broad geographic distribution and are commonly collected. *Trombicula akamushi,* so frequently mentioned in accounts of tsutsugamushi disease and the chief vector of this disease in Japan, is actually confined to a small area in Japan and only locally common. Although most species seem to have no well developed host specificity, a few species seem closely associated with one kind of mammal: *Trombicula himizu* is typically a parasite of the shrew-mole *(Urotrichus talpoides)* as is *T. miyairii* and *T. tenjin,* and bats *(Myotis macrodactylus)* are the only known host of *T. toshiokai.*

Key to Japanese Species of Leptotrombidium

1.	Ventral palpal tibial seta feathered	2
—	Ventral palpal tibial seta nude	5
2.	Lateral palpal tibial seta feathered	*T. (L.) miyajimai*
—	Lateral palpal tibial seta nude	3
3.	Anterolateral and posterolateral setae similar	*T. (L.) palpalis*
—	Posterolateral setae much heavier than anterolateral setae	4
4.	Posterolateral setae rasp-like, barbs short	*T. (L.) yasuokai*
—	Posterolateral setae pectinate, barbs long	*T. (L.) himizu*
5.	Seta on coxa III on anterior margin of coxa	6
—	Seta on coxa III markedly behind the anterior margin of coxa	7
6.	First post-humeral row of setae usually ten	*T. (L.) tanaka-ryoi*
—	First post-humeral row of setae usually eight	*T. (L.) fuji*
7.	Posterolateral setae in the angulate corners of the scutum	8
—	Posterolateral setae in the anterior part of the rounded posterior corners of the scutum	9

8. Sensillary bases in advance of the posterolateral setae; posterior margin of the scutum more or less straight..*T. (L.) akamushi*

— Sensillary bases about on a line with posterolateral setae; posterior margin of scutum evenly rounded..*T. (L.) scutellaris*

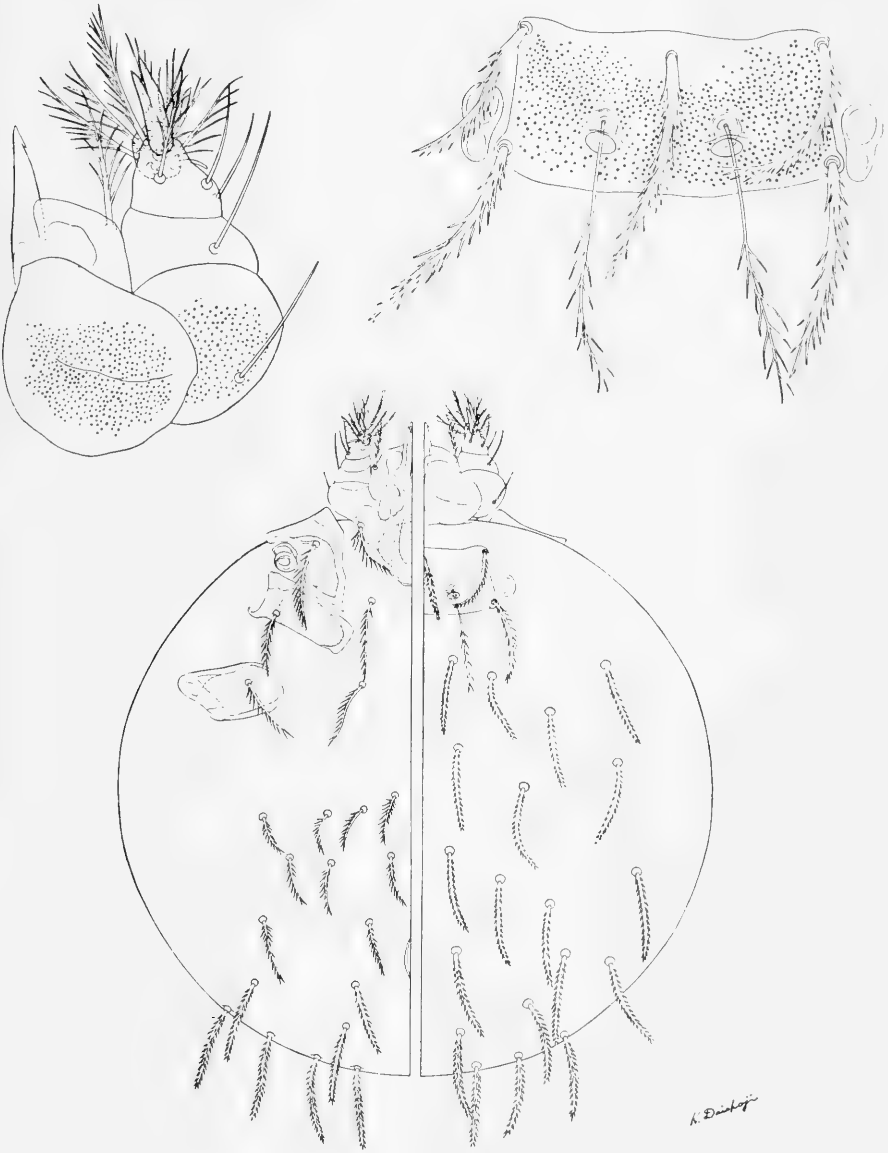


Fig. 27 *Trombicula akamushi*

9. Bases of sensillae nude .... 10[1]
— Bases of sensillae barbed 15
10. Sensillary bases about on a line with posterolateral setae 11
— Sensillary bases clearly behind a line connecting posterolateral setae 13
11. Ventral palpal tibial seta shorter than the palpal genual seta; first post-humeral row of setae usually eight .... *T. (L.) kuroshio*
— Ventral palpal tibial seta as long or longer than the palpal genual seta; first post-humeral row of setae usually ten 12
12. Scutum about twice as wide as long; dorsal setae rather long, with the barbs rather appressed .... *T. (L.) intermedia*
— Scutum about two and one-half times as wide as long; dorsal setae rather short and bushy .... *T. (L.) teramurai*
13. Scutum more than twice as wide as long; usually two pairs of humeral setae .... *T. (L.) miyazakii*
— Scutum less than twice as wide as long; a single pair of humeral setae 14
14. Dorsal setae with barbs short .... *T. (L.) tenjin*
— Dorsal setae with barbs very long (and few in number) .... *T. (L.) miyairii*
15. Basal barbs of sensillae divergent, conspicuous 18
— Basal barbs of sensillae delicate and appressed 16
16. Sensillary bases markedly behind a line connecting the posterolateral setae .... *T. (L.) miyairii*
— Sensillary bases approximately on a line connecting the posterolateral setae 17
17. Scutum slightly less than twice as wide as long; ventral and lateral palpal tibial setae subequal .... *T. (L.) toshiokai*
— Scutum slightly more than twice as wide as long; ventral palpal tibial seta much longer than lateral palpal tibial seta .... *T. (L.) intermedia*
18. First post-humeral row of setae 12–15; dorsal setae shorter than length of scutum .... *T. (L.) pallida*
— First post-humeral row of setae 8–10; dorsal setae longer than scutum 19
19. Dorsal setal formula 2–10–8–8–6–4–2 .... *T. (L.) tosa*[2]
— Dorsal setal formula 2–8–6–6–2–2 .... *T. (L.) kitasatoi*

Trombicula (Leptotrombidium) palpalis Nagayo *et al.*, 1919

(Figure 23)

Trombicula palpalis Nagayo, Mitamura, and Tamiya, 1919, Jikken Igaku Zasshi, vol. 3, no. 4, pp. 265–312.

Diagnosis: The ventral palpal tibial seta is feathered. Sensillary bases about on a line with the posterolateral setae. Sensillae basally nude (or

---

[1] Species in which the barbs are very minute will key out in both halves of this couplet.

[2] Possibly a synonym of *T. kitasatoi*.

with a few very small barbs), with numerous barbs on the distal half. Scutum approximately twice as broad as long; posterior corners well rounded, and posterolateral setae in the anterior part of these corners, well in advance of the posterior margin of the scutum. Specimens from mountain areas have a tendency to have more dorsal setae than specimens from

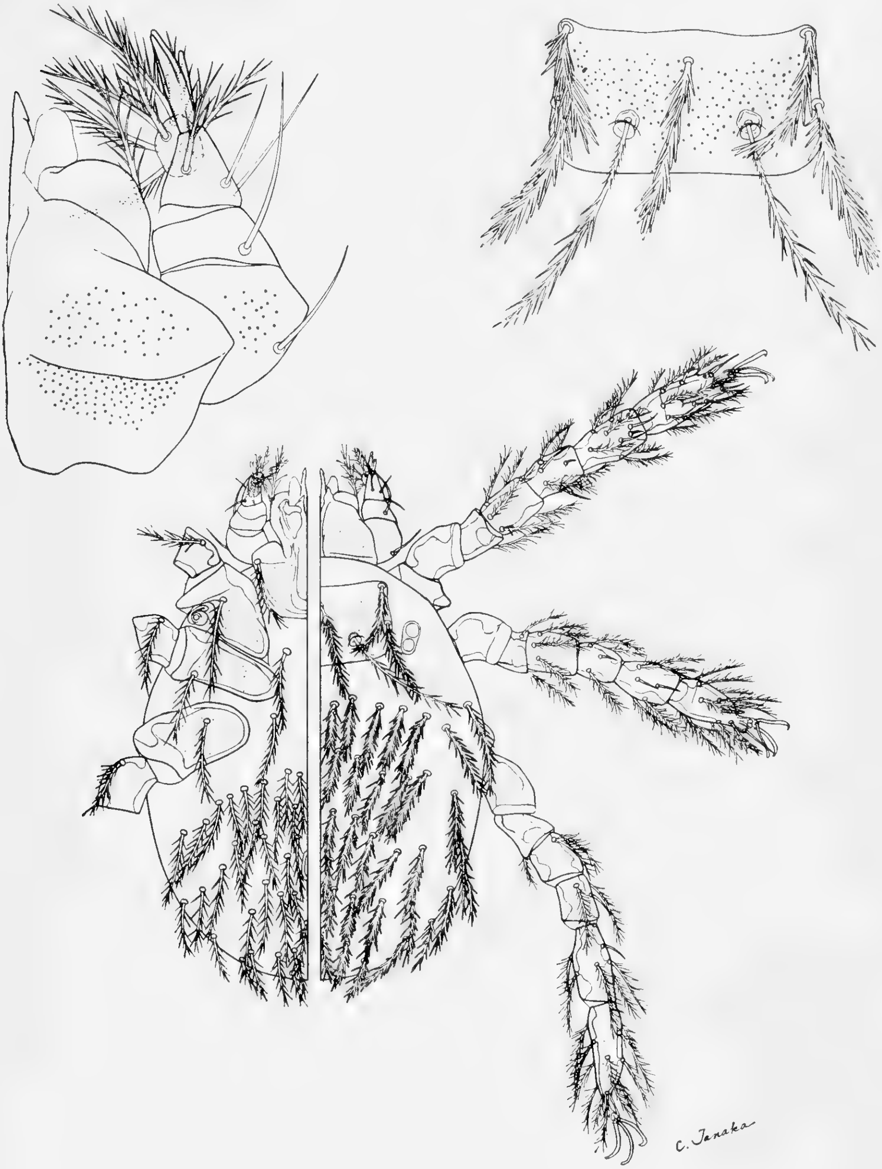


Fig. 28 *Trombicula pallida*

valleys and low grasslands. In such slightly aberrant mountain specimens, the rows of setae will be crowded and irregular.

DISTRIBUTION AND HOSTS: Saitama, Nanagawa, Gumma, Yamagata, Akita, Okayama, Yamanashi, and Ishikari prefectures from *Microtus montebelloi, Clethrionomys rufocanus, C. smithii, Apodemus speciosus, Rattus norvegicus, Urotrichus talpoides,* and *Passer montanus.* This chigger has also been collected in southern Korea.

TYPE DATA: A lectotype has been selected from specimens collected from *Microtus montebelloi* by the original authors at Yachi, Yamagata; March 27, 1919; deposited at Institute for Infectious Diseases, University of Tokyo.

Trombicula (Leptotrombidium) yasuokai Sasa *et al.,* 1952

(Figure 24)

Trombicula yasuokai SASA, KAWASHIMA, and HIROMATSU, 1952, Tokyo Iji Shinshi, vol. 69, no. 1, p. 43.

DIAGNOSIS: Ventral tibial seta of palpus feathered. Cheliceral base with scattered punctae. Sensillary bases markedly behind posterolateral setae. Sensillae basally nude, with scattered barbs on distal half. Hind margin of scutum more or less three sided: straight immediately behind and between the sensillae, and directly anteriorly near the posterolateral setae. Posterolateral and anteromedian setae distinctly heavier than anterolateral setae and with rasp-like, heavy barbs. Scutal measurements of holotype: AW–62.5, PW–81, SB–35, ASB–30, PSB–11.5, AP–19.5, AM–69.5, AL–43.5, PL–72.5, S–66.5

DISTRIBUTION AND HOSTS: Known from Kochi Prefecture from *Mogera wogura.*

TYPE DATA: Holotype and one paratype from Sakiyama, Muroto-machi, Kochi Prefecture from *Mogera wogura;* collected by Y. Hiromatsu, August 26, 1951. Holotype and paratype deposited at Institute for Infectious Diseases, University of Tokyo.

REMARKS: The original illustration shows the sensillary barbs to be short and scale-like, and the scutum to be evenly rounded on the hind margin near the posterolateral setae. The actual condition of the holotype is shown in the accompanying figure.

Trombicula (Leptotrombidium) himizu Sasa *et al.,* 1951

(Figure 25)

Trombicula himizu SASA, KUMADA, HAYASHI, ENOMOTO, FUKUZUMI, and OBATA, 1951, Eisei Doobutsu, vol. 2, no. 1, pp. 1–5.

DIAGNOSIS: Ventral tibial seta of palpus feathered. Sensillary bases behind posterolateral setae. Sensillae basally nude, with scattered barbs distally. Posterolateral setae in advance of the rounded posterior corners of the scutum. Anteromedian and posterolateral setae with very heavy shafts and rather stout barbs. The numerous dorsal setae similar in nature to the anteromedian and posterolateral setae of the scutum; the small number and large size of the barbs on these setae serve to separate *T. (L.) himizu* from the other species of *Leptotrombidium* with a feathered ventral tibial seta of the palpus. Scutal measurements of the holotype: AW–60.5, PW–72, SB–32, ASB–27.5, PSB–10.5, AP–19, AM–67, AL–44.5, PL–60.5, S–82.

Distribution and hosts: Kanagawa, Shizuoka, and Yamanashi prefectures, from *Urotrichus talpoides, Apodemus speciosus,* and *Microtus montebelloi.*

Type data: Holotype from Mt. Oyama, Kanagawa Prefecture, from *Urotrichus talpoides;* November 23, 1950. Three paratypes from the same host from Yamanaka, Yamanashi Prefecture, November 20, 1950. These

Fig. 29 *Trombicula tanaka-ryoi*

specimens are deposited at the Institute for Infectious Diseases, University of Tokyo; one specimen (paratype) deposited at the Kitasato Institute, Tokyo.

Trombicula (Leptotrombidium) miyajimai Fukuzumi and Obata, 1951

(Figure 26)

Trombicula miyajimai Fukuzumi and Obata, 1951, Kitasato Archives of Experimental Medicine, vol. 23, p. 5.

Diagnosis: This is the only species of *Leptotrombidium* in Japan in which all the palpal tibial setae are feathered. The cheliceral base and, dorsally, the segments of the palpus bear numerous punctae. Sensillary bases about on a line with posterolateral setae. Posterolateral setae set in the rather sharp corners of the scutum. Hind margin of the scutum projecting slightly in the area behind and between the sensillae. Sensillae basally nude and distally with 8–12 barbs. Posterolateral setae rather heavy and with short fine barbs. Dorsal setae long and similar to posterolateral setae of scutum. Scutal measurements of holotype: AW–71.8, PW–86.8, AP–28.3, ASB–35, PSB–14, SB–31.7, AM–57.9, AL–46.1, PL–80.4, S–64.2.

Distribution and hosts: Kanagawa, Kyoto, Chichibu, Okayama, Gumma, and Kochi prefectures from *Apodemus speciosus, A. geisha, Clethrionomys smithii,* and *Microtus montebelloi.*

Type data: Holotype and five paratypes from *Apodemus speciosus* from Matsuda, Kanagawa Prefecture; October 9, 1950. Holotype and paratypes deposited at the Kitasato Institute.

Trombicula (Leptotrombidium) akamushi (Brumpt, 1910)

(Figure 27)

Trombidium akamushi Brumpt, 1910, Prêcis de Parasitologie, 2nd ed., p. 506, Paris, Masson.

Diagnosis: Palpal femoral and genual setae nude; lateral and ventral palpal tibial setae nude; dorsal palpal tibial seta feathered. Galeal seta feathered. Cheliceral base and palpal femur with numerous small punctae. Sensillary bases well in advance of the posterolateral setae (*T. (L.) akamushi* is unique in this respect among Japanese species of *Leptotrombidium*). Sensillae nude basally, plumose distally. Posterolateral setae placed in the angulate corners of the scutum. Seta of coxa III markedly behind the anterior margin of coxa. Scutal measurements (mean of five specimens from Akita Prefecture, from Fukuzumi and Obata, 1951, Kitasato Archives of Experimental Medicine, 23:8): AW–65.5, PW–73.3,

AP–28.6, ASB–18.9, PSB–17.1, SB–28.9, AM–53.3, AL–42.9, PL–51.7, S–60.0.

Distribution and hosts: This species in Japan seems to occur only along the grassy areas in the valleys of the four main rivers in northwest-

Fig. 30 *Trombicula fuji*

ern Honshu: the Shinano and Agano rivers in Niigata Prefecture, the Mogami River in Yamagata Prefecture, and the Omono River in Akita Prefecture. The most common host is *Microtus montebelloi,* but *Rattus norvegicus, Apodemus speciosus,* and several species of wild birds are also parasitized.

TYPE DATA: From man; no type locality was designated, but Tanaka collected his original material from Yuzawa, Akita Prefecture

REMARKS: As Philip (1947, American Journal of Hygiene, vol. 46, p. 60) pointed out, the original description of *T. akamushi* consists of a poorly executed drawing. It is uncertain what species is intended from the illustration, but the species illustrated here is one that workers today generally agree to call *Trombicula akamushi.* It has long been accepted in the literature as the vector (and more recently, the major vector) of tsutsugamushi disease in Japan; there is nothing to be gained by a change of names. Actually, the identification of the species shown by Brumpt is probably no more difficult than that of many original descriptions of that period. The feathered condition of the palpal femoral and genual setae, clearly shown in the original figure, indicate that the species shown was not a species of *Leptotrombidium.* Quite possibly the species shown is *Trombicula (Neotrombicula) japonica.* Apparently early workers identified what we now call *T. akamushi* without referring to the original description, thus giving rise to a misidentification which workers have followed ever since. The present assignment of names should stand.

Trombicula (Leptotrombidium) pallida Nagayo *et al.,* 1919

(Figure 28)

Trombicula pallida NAGAYO, MITAMURA, and TAMIYA, 1919, Jikken Igaku Zasshi, vol. 3, pp. 265–312.

Trombicula burnsi SASA, TERAMURA, and KANO, 1950, Tokyo Iji Shinshi, vol. 67, no. 10, p. 22. *New synonymy.*

Trombicula murotoensis SASA and KAWASHIMA, 1951, Tokyo Iji Shinshi, vol. 68, no. 12, p. 16. *New synonymy.*

DIAGNOSIS: Scutum more or less rectangular, with the posterolateral setae well in the anterior part of the rounded posterior corners. Sensillary bases slightly behind a line connecting the posterolateral setae. Sensillae with conspicuous, and divergent (though small) basal barbs, distal two-thirds with branches. The dorsal setae in *T. pallida* are numerous, with 12–15 in the first post-humeral row; they are distinctive in being rather heavy and short with numerous barbs. Seta on coxa III placed well behind the anterior margin of the coxa. *Trombicula pallida* is highly variable, especially with regard to the number of dorsal setae. Scutal measurements of an average specimen: AW–72, PW–78, SB–36, ASB–33, PSB–15, AP–20, AM–54, AL–45, PL–72, S–60.

Distribution and hosts: This is a common and widely distributed species in Japan, and is known to occur also in southern Korea. Yamagata, Kanagawa, Saitama, Akita, and Kyoto prefectures, and Oshima and Miyake islands from *Crocidura dsi-nezumi, Apodemus speciosus, Clethrionomys smithii, Rattus norvegicus, Microtus montebelloi,* and small birds.

Type data: Lectotype selected from specimens collected by the original authors at Yachi, Yamagata Prefecture; March 27, 1919, from *Microtus montebelloi;* deposited at the Institute for Infectious Diseases, University of Tokyo.

Remarks: *Trombicula burnsi* and *T. murotoensis* are regarded as synonyms of *T. pallida.*

Fig. 31 *Trombicula kitasatoi*

Trombicula (Leptotrombidium) tanaka-ryoi Kawashima and Sasa, 1952

(Figure 29)

Trombicula tanaka-ryoi KAWASHIMA and SASA, 1952, Tokyo Iji Shinshi, vol. 69, no. 2, p. 21.

Trombicula tanaka-ryoi MITSUTOMI, SASA, HAYASHI, ETŌ, KOBAYASHI, and KITAHARA, 1952, Tokyo Iji Shinshi, vol. 69, no. 4, p. 18 (Original illustration).

DIAGNOSIS: Very close to *T. fuji* Kuwata *et al.,* 1950. *Trombicula tanaka-ryoi* differs in the shorter genual palpal seta, the larger scutum, and the dorsal setal formula. The scuta of the two species are remarkably similar, but in *T. tanaka-ryoi* the scutum is approximately twice as wide as long whereas in *T. fuji* it is less than twice as wide as long. The sensillary bases in both species are far behind a line connecting the posterolateral setae, and the sensillae possess conspicuous, divergent basal barbs in both species. In *T. tanaka-ryoi* the first post-humeral row of dorsal setae is usually ten and in *T. fuji* it is usually eight. In both species the seta on coxa III arises from the anterior margin of the coxa. Scutal measurements of holotype: AW–64, PW–64, SB–29, AP–17.5, SD–43, PSB–13, ASB–30, AM–44.5, AL–36, PL–62.5, S–56.5.

DISTRIBUTION AND HOSTS: Okayama, Kochi, Kyoto, Kumamoto, Oita, Shiga, Ehime, Mie, Tottori, Shimane, and Nara prefectures from *Crocidura dsi-nezumi, Apodemus speciosus,* and *Clethrionomys smithii.*

TYPE DATA: Holotype from Mt. Ishiguchi, Ehime Prefecture, from *Clethrionomys smithii;* collected by Ryo Tanaka; September 10, 1951. One paratype with the same data, and three paratypes from *Apodemus speciosus* with the same data. Deposited at the Institute for Infectious Diseases.

Trombicula (Leptotrombidium) fuji Kuwata *et al.,* 1950

(Figure 30)

Trombicula (Leptotrombidium) fuji KUWATA, BERGE, and PHILIP, 1950, Journal of Parasitology, vol. 36, p. 80.

DIAGNOSIS: The very long palpal genual seta of *T. fuji* is distinctive. The scutum is small and the sensillary bases are placed far behind a line connecting the posterolateral setae. The first post-humeral row of setae is almost always of eight setae. The seta on coxa III arises from the anterior margin of the coxa. (See also diagnosis for *T. tanaka-ryoi.*) Scutal measurements of holotype: AW–50.5, PW–52, SB–24, AP–14, SD–30.5, PSB–11, PL–SB–10.5, AM–29.5, AL–28.5, PL–51, S–40.5.

DISTRIBUTION AND HOSTS: Aomori, Akita, Yamagata, Niigata, Gumma, Saitama, Chiba, Tokyo, Kanagawa, Yamanashi, Nagano, Hyogo, Okayama, Shimane, Oita, Kumamoto, Shizuoka, Kyoto, Mie, Shiga, Fukuoka, and Kochi prefectures from *Apodemus speciosus, A. geisha, Rattus norvegicus,* *R. rattus, Clethrionomys smithii,* and *Microtus montebelloi.* Known also from the Pescadores.

Type data: From *Apodemus speciosus* from east slope of Mt. Fuji, Fujino Susuno (near Gotemba), Shizuoka Prefecture; October 30, 1948, collected by Major Trygve O. Berge; deposited at the United States National Museum.

Trombicula (Leptotrombidium) kitasatoi Fukuzumi and Obata, 1950

(Figure 31)

Trombicula kitasatoi Fukuzumi and Obata, 1950, Kitasato Archives of Experimental Medicine, vol. 23, no. 3, p. 79.

Diagnosis: Scutum more than twice as wide as long; posterolateral setae in the anterior part of the rounded corners of the scutum. Sensillary

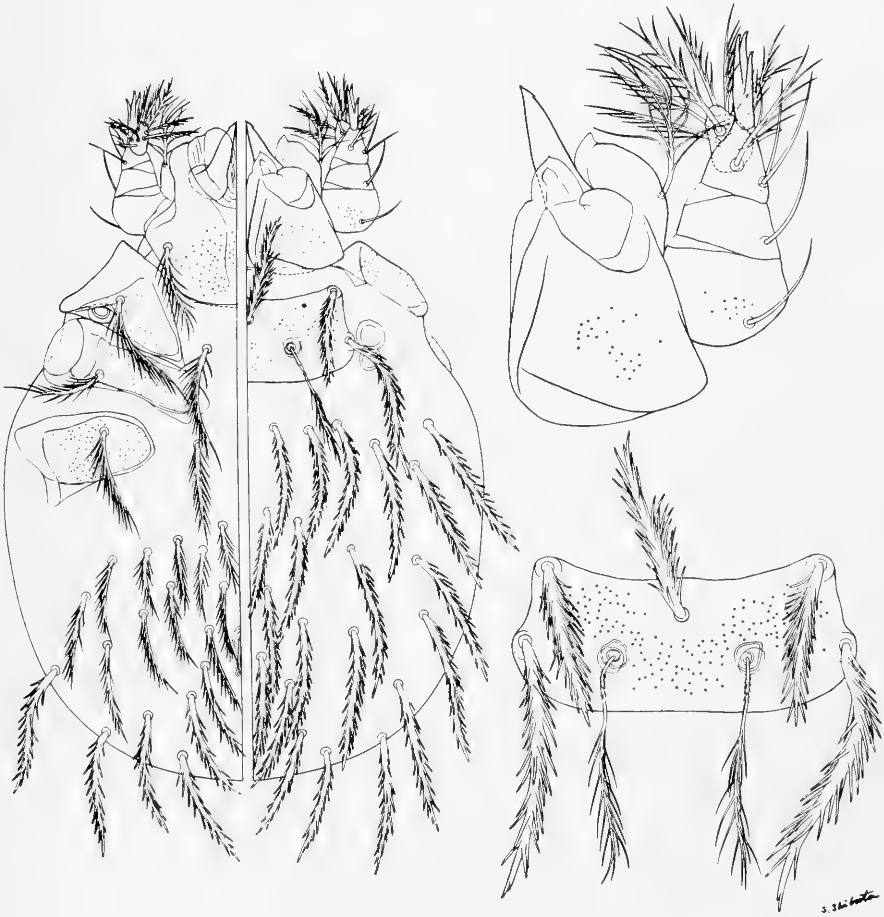


Fig. 32 *Trombicula tosa*

bases about on a line with posterolateral setae; basal third of sensillae with conspicuous, divergent barbs. First post-humeral row of dorsal setae usually eight. Seta of coxa III markedly behind the anterior margin of the coxa. Scutal measurements of holotype: AW–70.4, PW–79.2, AP–22.0, SB–33.9, ASB–25, PSB–15, AM–51.7, AL–40.0, PL–73.3, S–53.2.

DISTRIBUTION AND HOSTS: Common and widely distributed. Saitama, Yamagata, Fukushima, Kanagawa, Chiba, Gumma, Kyoto, Shiga, Mie, Okayama, Fukuoka, Kagoshima, Kumamoto, Oita, and Kochi prefectures from *Apodemus speciosus, A. geisha, Rattus norvegicus, R. rattus, Clethrionomys smithii,* and *Microtus montebelloi.*

TYPE DATA: From *Apodemus speciosus* from Tsurumi, Kanagawa Prefecture; September 9, 1950; collected by the original describers; deposited at the Kitasato Institute, Tokyo.

Trombicula (Leptotrombidium) tosa Sasa and Kawashima, 1951

(Figure 32)

Trombicula tosa SASA and KAWASHIMA, 1951, Tokyo Iji Shinshi, vol. 68, no. 10, p. 10.

DIAGNOSIS: Very similar to *T. kitasatoi,* differing only in the dorsal setal formula: in *T. tosa* it is 2–10–8–8–6–4–2 and in T. *kitasatoi* it is 2–8–6–6–2–2. In the original description the enlarged drawing of the scutum shows the hind margin to be evenly rounded but the holotype is as illustrated in the accompanying figure in this paper. Scutal measurements of holotype: AW–70, PW–78, SB–32, ASB–29, PSB–13, SD–42, AP–22, TM–52, AL–37, PL–65, S–56.

DISTRIBUTION AND HOSTS: From Kochi Prefecture from *Rattus norvegicus* and *R. Rattus.* This species is abundant in sweet potato fields and residential areas in the coast-line area of western Kochi. *Trombicula tosa* occurs exclusively in the summer months; from near-by areas of scrub and forest, *T. kitasatoi* occurs from autumn to spring.

TYPE DATA: Holotype and five paratypes from *Rattus norvegicus* from Ida, Kochi Prefecture; June 29, 1951; deposited at the Institute for Infectious Diseases.

REMARKS: When the biology and complete life histories of *T. kitasatoi* and *T. tosa* are better known, the latter may prove to be a biological variant or a synonym of *T. kitasatoi.* Among a series of specimens mounted on a single slide, five clearly belong to *T. tosa* and one definitely to *T. kitasatoi.*

Trombicula (Leptotrombidium) miyairii Sasa *et al.*, 1952

Figure 33)

Trombicula miyairii SASA, HAYASHI, KAWASHIMA, MITSUTOMI, and EGASHIRA, 1952, Tokyo Iji Shinshi, vol. 69, no. 3, p. 11.

Diagnosis: Gnathosoma similar to that of *T. akamushi.* Scutum small, about twice as wide as long; with posterior margin projected considerably behind the posterolateral setae. Sensillary bases considerably behind posterolateral setae. Bases of sensillae with minute barbs; distal half with two or three very long branches. Posterolateral setae heavy, with the shaft thick and the branches heavy and long. Dorsal body setae

Fig. 33 *Trombicula miyairii*

similar to posterolateral setae. Scutal measurements of holotype: AW–59, PW–60, SB–29, ASB–31, PSB–14, AP–15, AM–40.5, AL–35, PL–62, S–52.

DISTRIBUTION AND HOSTS: To date all specimens have been collected from *Urotrichus talpoides* from Kumamoto, Oita, and Ehime prefectures.

TYPE DATA: Holotype from *Urotrichus talpoides* from Toshita (near Mt. Aso), Kumomoto Prefecture; October 21, 1951; three paratypes with the same data; two paratypes from Mt. Ishijuchi, Ehime Prefecture; September 8, 1951. Holotype and all paratypes deposited at Institute for Infectious Diseases.

Trombicula (Leptotrombidium) tenjin Sasa *et al.,* 1951

(Figure 34)

Trombicula tenjin SASA, HAYASHI, KUMADA, and MIURA, 1951, Tokyo Iji Shinshi, vol. 68, no. 3, p. 17.

DIAGNOSIS: Gnathosoma similar to that of *T. akamushi;* the branched palpal setae with fewer and longer branches. Scutum about twice as wide as long; with numerous scattered punctae; posterior margin projected far behind posterolateral setae, with a slight mesal concavity. Sensillary bases far behind a line connecting the posterolateral setae. Sensillae rough and rasp-like basally, with six to eight rather long barbs on the distal half or two-thirds. Barbs on scutal setae rather heavy, not especially long. Dorsal setae similar to scutal setae. Scutal measurements of holotype: AW–63.0, PW–70.0, AP–21.5, ASB–28.0, PSB–10.0, SB–30.5, AM–41.0, AL–38.0, PL–80.5, S–48.5.

DISTRIBUTION AND HOSTS: Known from Kanagawa Prefecture from *Urotrichus talpoides.*

TYPE DATA: From *Urotrichus talpoides* from Okuyugawa, Kanagawa Prefecture; November 12, 1950; deposited at the Institute for Infectious Diseases.

Trombicula (Leptotrombidium) teramurai Sasa *et al.,* 1951

(Figure 35)

Trombicula teramurai SASA, KUMADA, and TERAMURA, 1951, Tokyo Iji Shenshi, vol. 68, no. 9, p. 8.

DIAGNOSIS: Gnathosoma similar to that of *T. akamushi.* Scutum more than twice as wide as long (almost three times as wide as long); lateral margins markedly concave; posterior margin projected considerably behind posterolateral setae, but slightly concave mesally; with scattered punctae. Sensillary bases slightly behind a line connecting posterolateral setae.

Bases of sensillae nude; distal two-thirds plumose. Dorsal setae rather short and plumose, as illustrated. Scutal measurements of holotype: AW–70, PW–80, SB–31, ASB–28, PSB–14, AP–17, AM–59, AL–38, PL–58.5, S–67.

Fig. 34 *Trombicula tenjin*

DISTRIBUTION AND HOSTS: From Niigata, Akita, and Yamagata from *Microtus montebelloi, Apodemus speciosus,* and *Urotrichus talpoides.*

TYPE DATA: Holotype and twelve paratypes from *Microtus montebelloi* from Akakura, Niigata Prefecture; April 24, 1951; deposited at Institute for Infectious Diseases.

REMARKS: The original illustration of the scutum errs in showing it too narrow; the illustration in this paper, made from the holotype, is accurate.

Trombicula (Leptotrombidium) kuroshio Sasa and Kawashima, 1952

(Figure 36)

Trombicula kuroshio SASA and KAWASHIMA, 1952, Tokyo Iji Shinshi, vol. 68, no. 12, p. 15.

DIAGNOSIS: Gnathosoma similar to that of *T. akamushi;* genual seta distinctly longer than ventral tibial seta. Scutum more than twice as wide as long; posterior corners more or less rounded. Sensillary bases distinctly behind a line connecting posterolateral setae. Base of sensillae nude, distal two-thirds plumose. The posterior margin of the scutum is usually more or less three-sided, sometimes irregularly rounded. Scutal measurements of holotype: AW–55, PW–63, SB–24, ASB–27, PSB–10, AP–16, AM–37, AL–32.5, PI–59, S–47.

DISTRIBUTION AND HOSTS: From Kagoshima, Kumamoto, Oita, and Shiga prefectures, from *Apodemus speciosus* and *Clethrionomys smithii.*

TYPE DATA: Holotype and seven paratypes from *Apodemus speciosus* from Maruyama, Muroto-machi, Kochi Prefecture; August 26, 1951; deposited at the Institute for Infectious Diseases.

Trombicula (Leptotrombidium) toshiokai Sasa and Jameson, new species

(Figure 37)

This species is one of two kinds of chiggers collected from bats in Japan; it is known only from this host.

GNATHOSOMA: Cheliceral base with a few punctae; a few small punctae on dorsal part of palpal femur. Chelicera with a subapical dorsal tooth. Palpal setae essentially as in *T. akamushi*: femoral, genual, and lateral and ventral tibial setae nude; dorsal tibial seta feathered. Galeal seta feathered.

LEGS: All coxa unisetosa; seta on coxa III distinctly behind the anterior margin of the coxa. Specialized (nude) setae: Leg I, 2 genulae, 1 microgenuala, 2 tibialae, 1 microtibiala, 1 spur, 1 microspur, 1 subterminala, 1 parasubterminala, 1 pretarsala; Leg II, 1 genuala, 2 tibialae, 1 spur, 1 pretarsala; Leg III, 1 genuala, 1 tibiala.

SCUTUM: About twice as wide as long (in *T. intermedia* and *T. miyazakii* the scutum is at least slightly more than twice as wide as long). Sen-

Fig. 35 *Trombicula teramurai*

sillary bases slightly behind a line connecting the posterolateral setae. Sensillae with minute and inconspicuous basal barbs, distal half plumose. Posterior margin of the scutum rounded, concave mesally. Punctae few. Scutal measurements of holotype: AW–91, PW–110, SB–48, ASB–42, PSB–18, AP–35, AM–77, AL–59, PL–84, S–70.

Fig. 36 *Trombicula kuroshio*

Setae: Dorsal setae quite long, with few barbs. Dorsal setae formula: 2–14(12–15)–12–10(10–12)–8–4. Sternal setae 2–2. About 45–50 small setae behind sternal setae, ventrally.

Type data: Holotype and ten paratypes from *Myotis macrodactylus* from the bat caves at Nikko, Tuchigi Prefecture; collected by Seiichi Toshioka and William Suyemoto, September 4, 1952; two additional specimens from the same host from Kyoto Prefecture collected by Yukio Shogaki and J. McClendon. Holotype and five paratypes deposited in United States National Museum; one paratype deposited in Institute for Infectious Diseases, University of Tokyo.

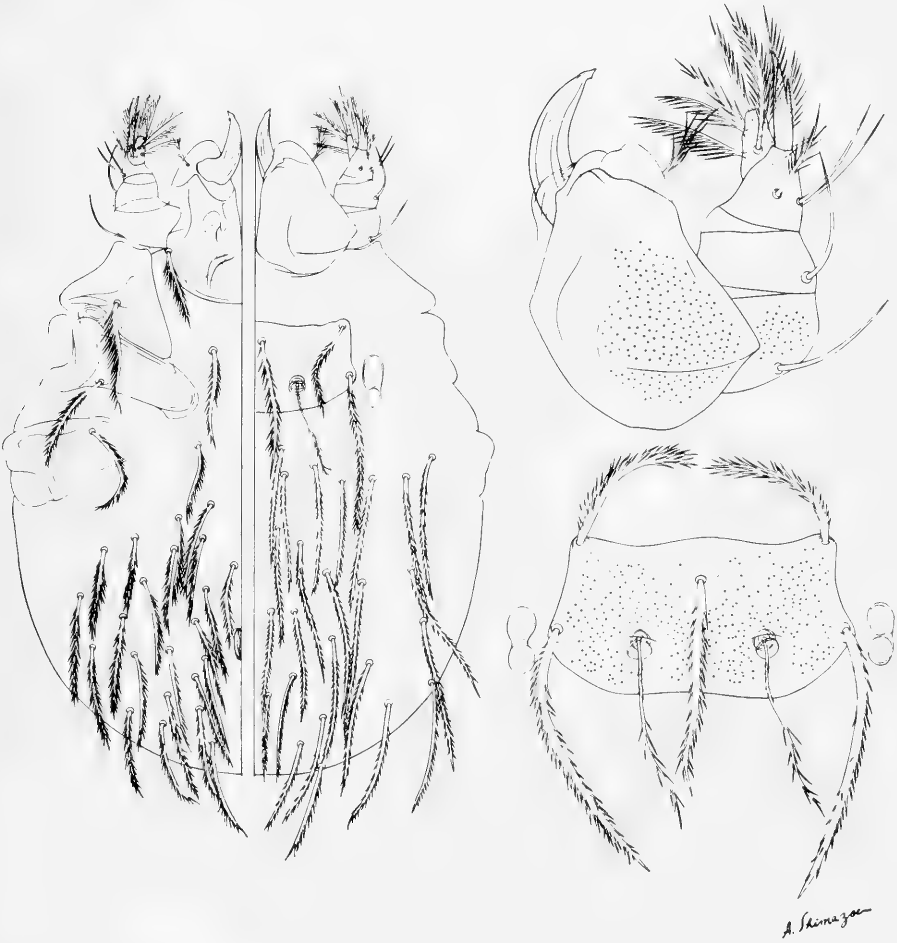


Fig. 37 *Trombicula toshiokai*

Trombicula (Leptotrombidium) miyazakii Sasa *et al.*, 1951

(Figure 38)

Trombicula miyazakii Sasa, Sawada, Kano, Hayashi, and Kumada, 1951, Tokyo Iji Shinshi, vol. 68, no. 4, p. 7.

Fig. 38 *Trombicula miyazakii*

DIAGNOSIS: Gnathosoma similar to that of *T. akamushi.* Scutum slightly more than twice as wide as long; posterolateral setae in the anterior part of the rounded posterior corners. Sensillary bases slightly behind a line

Fig. 39 *Trombicula intermedia*

connecting the posterolateral setae. Basal third of sensillar nude, distal two-thirds plumose. First two post-humeral rows of dorsal setae very close together, together with about twenty setae. Two pairs (usually) of humeral setae. Dorsal setae much more numerous than in most Japanese species of *Leptotrombidium.* Scutal measurements of holotype: AW–80, PW–91, AP–25, SB–40.5, ASB–25.5, PSB–17.5, AM–64, AL–46.5, PL–71.5, S–76.

DISTRIBUTION AND HOSTS: Gumma, Kanagawa, Saitama, Gifu, Nagano, and Ehime prefectures from *Apodemus speciosus* and *Clethrionomys smithii.*

TYPE DATA: A holotype and a paratype from *Apodemus speciosus* from Ikao, Gumma Prefecture, November 27, 1950; deposited at the Institute for Infectious Diseases, University of Tokyo.

Trombicula (Leptotrombidium) intermedia Nagayo *et al.,* 1920

(Figure 39)

Trombicula intermedia NAGAYO, MITAMURA, and TAMIYA, 1920, Verhandelingen Japanische Pathologische Gesellschaft, vol. 10, p. 147.

DIAGNOSIS: Gnathosoma similar to that of *T. akamushi,* but with the ventral tibial seta of the palpus very long. Scutum with the rear margin convex with a slight mesal concavity; hind corners rounded; the outline of the rear margin is quite variable. Sensillary bases about on a line with the posterolateral setae. Basal third of sensillae with minute, inconspicuous barbs; distal two-thirds of sensillae plumose. Dorsal setae rather long, with barbs short. Scutal measurements (from Fukuzumi and Obata, 1950, Kitasato Archives of Experimental Medicine, 23:81): "AW–68.6, PW–80.7, AP–25.3, ASB–20.7, PSB–12.8, SB–36.5, AM–50.6, AL–44.0, PL–62.5, S–66.0."

DISTRIBUTION AND HOSTS: This species is very common and widely distributed throughout the mountain areas of eastern Honshu and Kokkaido: Akita, Yamagata, Niigata, Aomori, Ishikari, Gumma, Yamanashi, Shizuoka, Nagano, Kyoto, Shiga, and Oita prefectures. It is known from *Urotrichus talpoides, Apodemus speciosus, Clethrionomys smithii, C. rufocanus,* and *Microtus montebelloi.*

TYPE DATA: The original description is based on specimens collected at Arato, Yamagata Prefecture. A lectotype (remounted) selected from the original series, was collected from *Microtus montebelloi;* Arato, Yamagata Prefecture; October 20, 1920; deposited at the Institute for Infectious Diseases, University of Tokyo.

Trombicula (Leptotrombidium) scutellaris Nagayo *et al.*, 1921

Figure (40)

Trombicula scutellaris Nagayo, Miyagawa, Mitamura, Tamiya, and Tenjin, 1921, American Journal of Hygiene, vol. 1, pp. 569–591. (In nos. 5 and 6, September-November, 1921.)

Trombicula scutellaris Nagayo, Mitamura, Tamiya, and Tenjin, 1931, Verhandelingen Japanische Pathologische Gesellschaft, vol. 11, p. 471. (December, 1921.)

Diagnosis: Gnathosoma similar to that of *T. akamushi;* in *T. scutellaris* the ventral tibial seta of the palpus is very long whereas this seta in *akamushi* is quite short. Scutum similar to that of *T. akamushi* in that the posterolateral setae are placed in the rather angulate corners of the scutum; the sensillary bases are, however, about on a line with the posterolateral

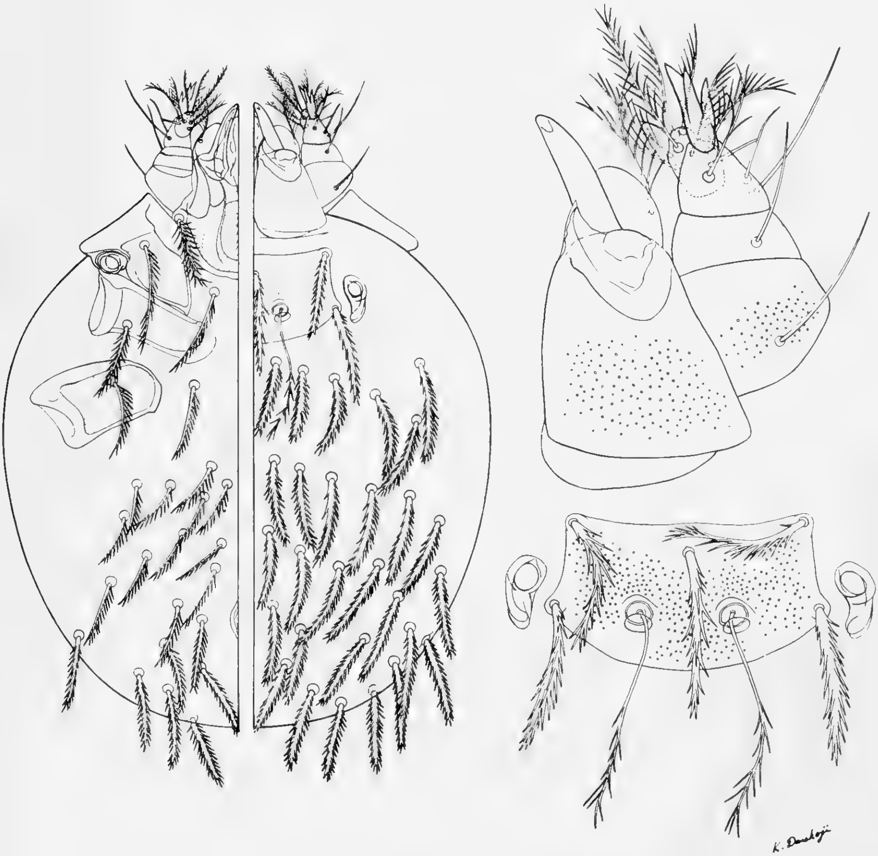


Fig. 40 *Trombicula scutellaris*

setae (in *T. akamushi* the sensillary bases are distinctly in advance of the posterolateral setae). The rear margin of the scutum is convex and evenly rounded. The bases of the sensillae are nude, the distal half plumose. Seta on coxa III distinctly behind the anterior margin of the coxa. Scutal measurements of a topotype (from Kuwata *et al.*, 1950, Journal of Parasitology, vol. 36, p. 82): "AW–69.5, PW–82.5, AP–31.5, SB–31.5, PSB–19.5, AM–62, AL–52.5, PL–64, S–76.5."

DISTRIBUTION AND HOSTS: Known from Yamagata, Nagano, Niigata, Kagoshima, and Shizuoka prefectures and from the Izu Islands (south of Tokyo), from *Microtus montebelloi, Apodemus speciosus, Rattus norvegicus,* and several species of wild birds.

TYPE DATA: This species was first recognized as a distinct species by Kawamura in Niigata, but was described as new by Nagayo *et al.,* based on specimens collected at Yachi, Yamagata Prefecture, from *Microtus montebelloi*; October 24, 1920. A holotype is not preserved. A lectotype (remounted separately) is deposited at the Institute for Infectious Diseases, University of Tokyo.

REMARKS: In the Izu Islands *T. scutellaris* is the suspected vector of Shichito fever, a form of tsutsugamushi disease.

Subgenus **Eutrombicula** Ewing, 1938

Species of *Eutrombicula* commonly infest birds and reptiles, and not infrequently attack man, causing an irritating dermatitis. The palpal claw is two pronged, the axial prong being dorsal (or external); there are 20 or 22 dorsal setae; and with one or more mastitarsalae III. Only one species is known from Japan.

Trombicula (Eutrombicula) wichmanni (Oudemans, 1905)

(Figure 41)

Thrombidium wichmanni OUDEMANS, 1905, Entomologische Berichten, vol. 1, no. 22, p. 217.

Trombicula wichmanni SASA and KANO, 1950, Tokyo Iji Shinshi, vol. 67, no. 4, p. 9.

DIAGNOSIS: Palpal femoral seta feathered; palpal genual seta nude; dorsal and lateral setae of palpal tibia nude, and ventral tibial seta feathered. Palpal claw two pronged, the axial prong dorsal (or external). Spur on palpal thumb rather short. Galeal seta nude. Sternal setae 2–2. Coxal setae 1–1–1. One mastitarsala III. Sensillary bases well in advance of posterolateral setae. Sensillae basally nude, with 5–8 barbs on distal half.

Twenty or twenty-two dorsal setae. Scutal measurements of a specimen from Japan: AW–90, PW–108, SB–45, ASB–36, PSB–40, AP–39, AM–46, AL–45, PL–56, S–51.

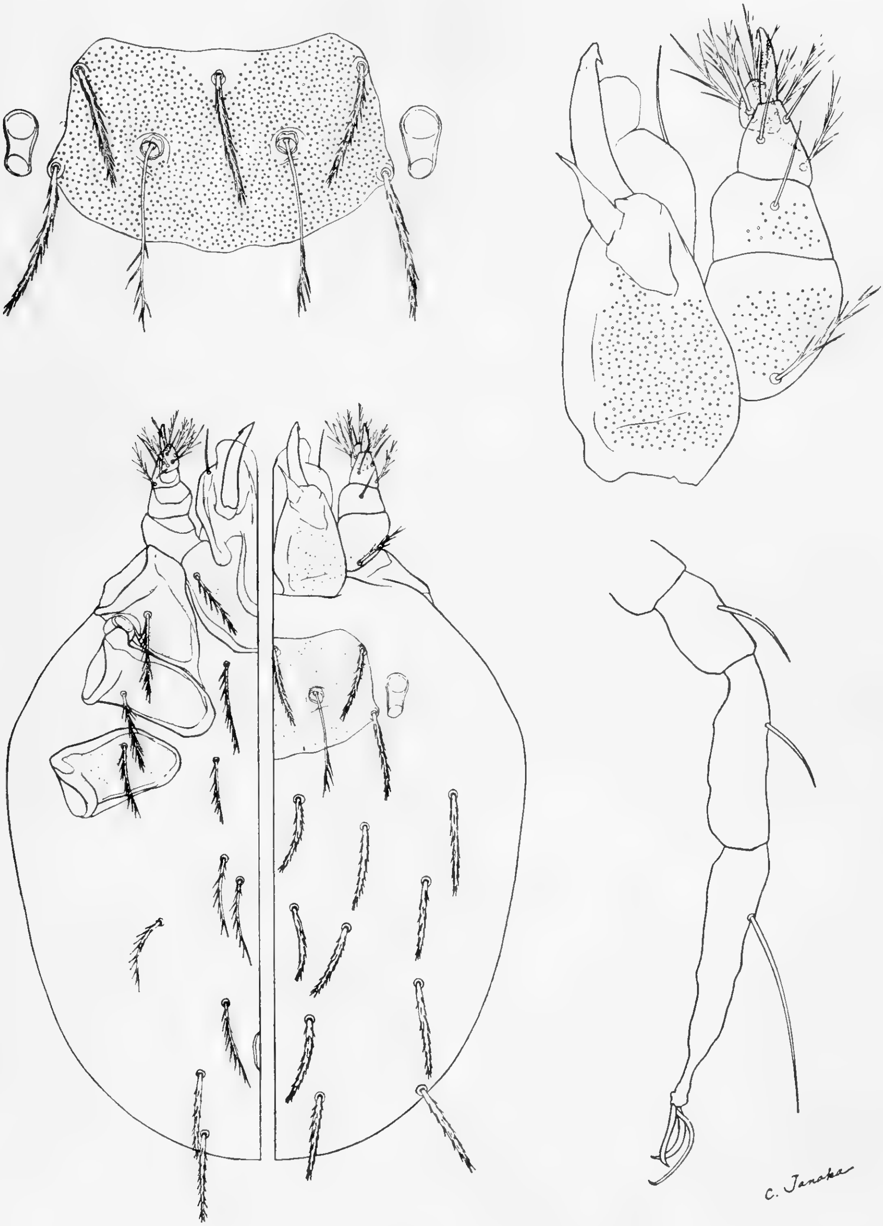


Fig. 41 *Trombicula wichmanni*

DISTRIBUTION AND HOSTS: This chigger is widely distributed in the warmer regions of the Orient. In Japan it occurs on Koshima and Hachijo islands (south of Tokyo) on *Rattus norvegicus,* wild birds, dogs, cats, and man.

TYPE DATA: Taken originally from the crowned pigeon from New Guinea and from man in North Celebes.

Ungrouped Species of Trombicula

The following species are placed together for convenience; they are not necessarily closely allied. It would create an erroneous impression to place them in a subgenus together, although some authors have so treated those species of *Trombicula* that do not fit into any of the established subgenera of *Trombicula.*

The first two species *(T. anous* and *T. shiraii)* would fall into the genus (or subgenus) *Acariscus* Ewing which we do not recognize; these two species seem both biologically and morphologically allied. *Trombicula koomori* and *T. hasegawai* are unrelated to each other and to other chiggers in Japan.

KEY TO UNGROUPED SPECIES OF TROMBICULA IN JAPAN

1.	Palpal claw two-pronged; 1 mastitarsala III	2
—	Palpal claw three-pronged; no mastitarsala III	3
2.	Sternal setae 2–2	*T. anous*
—	Sternal setae 2–4	*T. shiraii*
3.	Posterior margin of scutum straight; bases of sensillae nude	*T. hasegawai*
—	Posterior margin of scutum bluntly pointed; bases of sensillae with conspicuous barbs	*T. koomori*

Trombicula anous (Wharton, 1945)

(Figure 42)

Acariscus anous WHARTON, 1945, Journal of Parasitology, vol. 31, p. 403.
Trombicula anous, KANO and SASA, 1952, Tokyo Iji Shinshi, vol. 69, no. 10, p. 15.

DIAGNOSIS: Palpal femoral and genual setae feathered; palpal tibial setae nude. Spur on palpal thumb very long and slender. Palpal claw two pronged, axial prong internal (or ventral). Galeal seta nude. Sternal setae 2–2. Coxal setae 1–1–1. Dorsal setae 32. Sensillae basally nude, with 5–7 barbs on the distal third. Sensillary bases well in advance of posterolateral setae. One mastitarsala III. Scutal measurements (mean of five specimens) as given by the describer: "AW–93, PW–101, SB–37, ASB–32, PSB–19, AP–30, AM–32, AL–53, PL–75, S–73." Scutal measurements of a specimen from Miyake Island, south of Tokyo: AW–84, PW–89, SB–28.5, ASB–38, AP–32, AL–49, PL–81, S–84.

Fig. 42 *Trombicula anous*

Distribution and hosts: Originally known from *Anous stolidus* and *Heteroscelus incanus* from Guam. Two specimens from *Pluvialis dominicus* from Miyake Island, Japan.

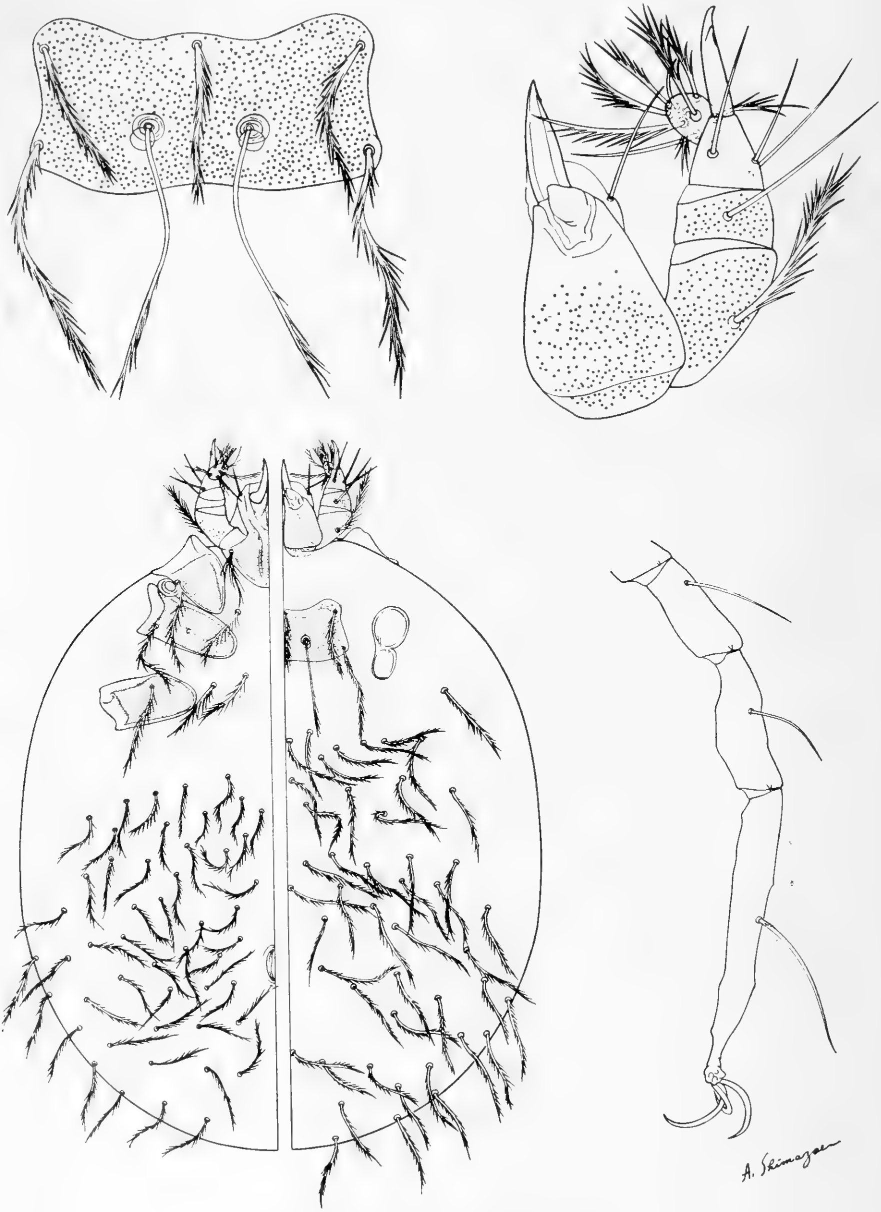


Fig. 43 *Trombicula shiraii*

TYPE DATA: Type host not indicated; from Ypao Point, Guam, Mariana Islands. Holotype in the United States National Museum.

Trombicula shiraii Sasa, Kano, and Ogata, 1952

(Figure 43)

Trombicula shiraii SASA, KANO, and OGATA, 1952, Tokyo Iji Shinshi, vol. 69, no. 10, p. 14.

DIAGNOSIS: Femoral seta of palpus feathered; palpal genual and tibial setae nude. Palpal claw two pronged, axial prong internal (or ventral). Spur on palpal thumb long and slender. Galeal seta nude. Cheliceral base and palpal femur and genu with numerous punctae. Scutum more or less rectangular, about twice as broad as long. Sensillary bases in advance of posterolateral setae. Sensillae with basal half nude, with 5–7 barbs dis-

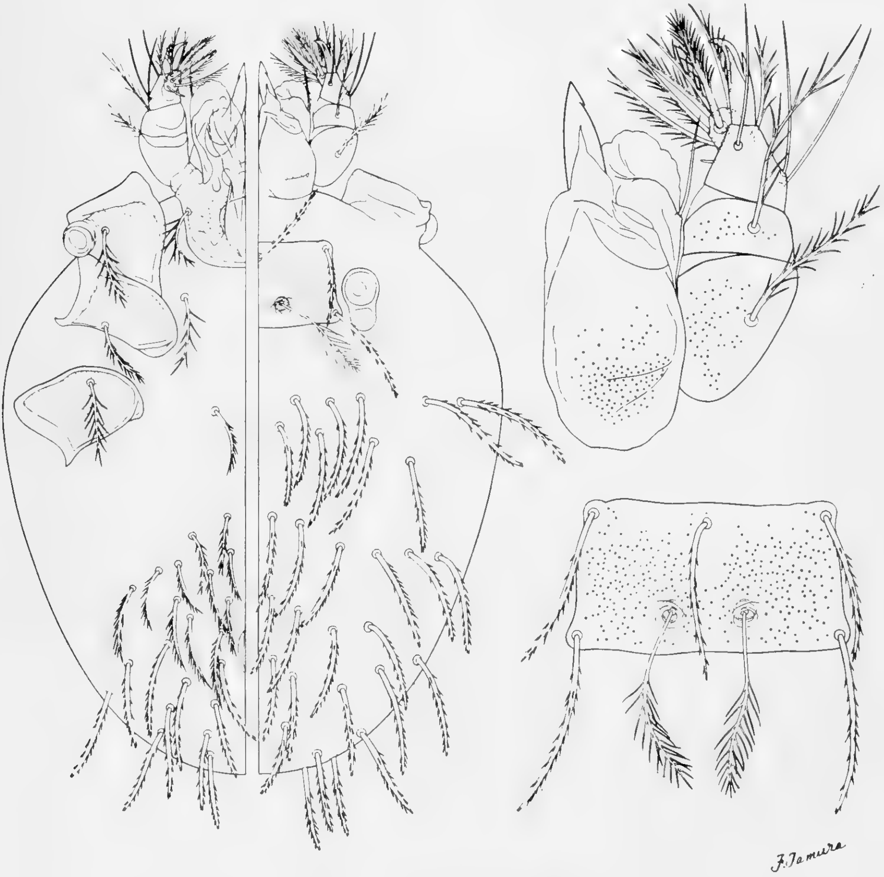


Fig. 44 *Trombicula hasegawai*

tally. Scutum with numerous punctae. Sternal setae 2–4. Coxal setae 1–1–1. One mastitarsala III. About 90 dorsal setae. Scutal measurements of holotype: AW–80.5, PW–89, SB–29.5, ASB–35, AP–32.5, AM–61, AL–49.5, PL–82, S–82.5.

Distribution and hosts: Known only from the original collection.

Type data: Holotype and one paratype from *Charadrius dominicus* from Tokyo; May 1, 1952. Holotype at Institute for Infectious Diseases, University of Tokyo.

Trombicula hasegawai Sasa *et al.*, 1953

(Figure 44)

Trombicula hasegawai Sasa, Hayashi, and Kawashima, 1953, Tokyo Iji Shinshi, vol. 70, no. 4, p. 15.

Diagnosis: Palpal femoral and genual setae feathered; palpal tibial setae nude. Galeal seta nude. Palpal claw three-pronged. Cheliceral base and palpal femur and genu with fine punctae. Scutum rectangular, with posterior margin straight. Posterolateral setae in the rather angular corners of the scutum. Sensillary bases in advance of a line connecting the posterolateral setae. Bases of sensillae nude; distal half plumose. Two pairs of humeral setae. First two post-humeral rows of setae close together and appearing as a single irregular row of setae; fifty or more dorsal setae. Sternal setae 2–2. Coxal setae 1–1–1. Scutal measurements of holotype: AW–71.5, PW–80, SB–22, ASB–35, PSB–13.5, AP–35.5, AM–52, AL–48.5, PL–61, S–56.

Distribution and hosts: Known only from the type locality from *Turdus celaeonops, Passer montanus, Streptopelia orientalis, Janthoenas janthrine,* and *Monticola solitarius.*

Type data: Holotype and 10 paratypes from *Turdus celaeonops,* from Hachijo Island (south of Tokyo); September 4–10, 1952. Deposited at Institute for Infectious Diseases, University of Tokyo.

Trombicula koomori Sasa and Jameson, new species

(Figure 45)

This species appears to have no close relatives in Japan, and is not very much like other known bat chiggers.

Gnathosoma: Cheliceral base with few punctae. Palpal femoral, genual, and lateral and ventral tibial setae all feathered; dorsal tibial seta nude and very long (exceeding the tip of the palpal claw). Palpal thumb with four feathered setae; the spur rather short, its length about equal to the width of the palpal thumb. Palpal claw three-pronged. Galeal seta nude. Chelicera twisted apically, with no projections laterally or subapically.

Fig. 45 *Trombicula koomori*

SCUTUM: Slightly wider than long; posterior margin produced and somewhat pointed; with conspicuous scattered punctae. One of the three original specimens possesses two anteromedian setae. Sensillary bases in advance of posterolateral setae. Sensillae with conspicuous and somewhat divergent basal barbs, and with 8–10 long branched on the distal two-thirds. Scutal measurements of holotype: AW–62, PW–64, SB–23, ASB–32, PSB–23, AM–38, AL–42, PL–60, S–54.

LEGS: Coxae with punctae; other segments with few punctae or none. Coxae unisetose. Nude setae on legs: Leg I, 2 genualae, 1 microgenuala, 2 tibialae, 1 spur, 1 microspur, 1 subterminala, 1 parasubterminala, 1 pretarsala; Leg II, 1 genuala, 2 tibialae, 1 spur, 1 microspur, 1 pretarsala; Leg III, 2 genualae, 1 tibiala.

SETAE: Dorsal setae slender and feathered, similar to the posterolateral setae. Dorsal setae in seven rows; dorsal setal formula: 2–14–10–8–8–6–4. Sternal setae 2–2. Ventral setae behind sternal setae 50–55.

DISTRIBUTION AND HOSTS: In Japan known only from the type collection. Taken also in southern Korea from the type host.

TYPE DATA: Holotype and two paratypes from *Rhinolophus ferrumequinum* (Schreber); near Ohara, Kyoto Prefecture; August 26, 1952; collected by Y. Shogaki and J. McClendon. Holotype in the United States National Museum; paratypes in Rocky Mountain Laboratory (Hamilton, Montana) and Institute for Infectious Diseases, University of Tokyo (Tokyo).

REMARKS: The specific name is the Japanese word for bat.

LITERATURE CITED

BRENNAN, JAMES M.

1951. Two new species of *Neöschongastia* with a key to the species of the world (Acarina: Trombiculidae). *Journal of Parasitology*, vol. 37, no. 6, pp. 577–582.

1952. The genus Pseudoschöngastia Lipovsky, 1951, with the description of two new species and a key to the world species, also Neoschöngastia paenitens, new name for Neoschöngastia kohlsi, Brennan, 1951, preoccupied (Acarina, Trombiculidae). *Proceedings of the Entomological Society of Washington*, vol. 54, no. 3, pp. 133–137.

BRENNAN, JAMES M. and GEORGE W. WHARTON

1950. Studies on North American chiggers. No. 3. The subgenus Neotrombicula. *American Midland Naturalist*, vol. 44, no. 1, pp. 153–197.

BRUMPT, E.

1910. Precis de Parasitologie, 2nd Edition. Masson, Paris, 915 pp.

EWING, H. E.

1928. A preliminary key to the larvae of fifteen species of the mite genus *Trombicula*, with descriptions of four new species. *Proceedings of the Entomological Society of Washington*, vol. 30, no. 2, pp. 77–80.

FUKUZUMI, SADAKICHI and YOSHIO OBATA

1950. A new species of trombiculid mite from the vicinity of Yokohama in Japan. *Kitasato Archives of Experimental Medicine*, vol. 23, no. 3, pp. 79–81.

1951. A new species of trombiculid mite found in Kanagawa Prefecture in Japan. *Kitasato Archives of Experimental Medicine*, vol. 23, no. 4, pp. 5–9.

1953. On five new species of trombiculid mites (Acarina) recovered in Miyakejima Island. *Kitasato Archives of Experimental Medicine*, vol. 26, no. 1, pp. 1–22.

JAMESON, E. W., JR. and MANABU SASA

1953. *Trombicula (Trombiculindus) kansai*, a new chigger from central Honshu, Japan. *Journal of Parasitology*, vol. 39, no, 3, pp. 247–249.

KAWASHIMA, FUMIO and MANABU SASA

1952. Study of tsutsugamushi. No. 19. On new trombiculid mites collected in Shikoku, Japan. *Tokyo Iji Shinshi*, vol. 69, no. 2, p. 21.

KUWATA, TSUGUO, T. O. BERGE, and CORNELIUS B. PHILIP

1950. A new species of Japanese larval mite from a new focus of tsutsugamushi disease in southeastern Honshu, Japan. *Journal of Parasitology*, vol. 26, no. 1, pp. 80–83.

MITSUTOMI, SHINGO, MANABU SASA, SHIGEO HAYASHI, MASAYOSHI EGASHIRA, KASUO KOBAYASHI and KEITA KITAHARA

1952. Study of tsutsugamushi. No. 21. On chigger mites in the mountain area of Kyushu. *Tokyo Iji Shinshi*, vol. 69, no. 4, p. 18.

NAGAYO, MATARO, TOKUSHIRO MITAMURA and TAKEO TAMIYA

1919. Three species of the tsutsugamushi. *Jikkan Igaku Zasshi*, vol. 3, no. 4, pp. 265–313.

1920. On the species of tsutsugamushi and their significance to tsutsugamushi disease. *Verhandelingen Japanische Pathologische Gesellschaft*, Bd. 10, pp. 142–147.

NAGAYO, MATARO, YONEJI MIYAGAWA, TOKUTARO MITAMURA, TAKEO TAMIYA, and SATORU TENJIN

1921. Five species of tsutsugamushi (the carrier of Japanese river fever) and their relation to the tsutsugamushi disease. *American Journal of Hygiene*, vol. 1, nos. 5 and 6, pp. 569–591.

OUDEMANS, A. C.

1905. Acarologische Aanteekeningen, 16. *Entomologische Berichten*, Bd. 1, pp. 216–218.

Philip, Cornelius B.

1947. Observations on tsutsugamushi disease (mite borne or scrub typhus) in northwestern Honshu Island, Japan, in the fall of 1945. I. Epidemiological and ecogical data. *American Journal of Hygiene*, vol. 46, no. 1, pp. 45–59.

Philip, Cornelius B. and H. S. Fuller

1950. The harvest mites ('Akidani') of Japan and the Far East and their relationship to the *autumnalis* group of trombiculid mites. *Parasitology*, vol. 40, nos. 1 and 2, pp. 50–57.

Sasa, Manabu, Shigeo Hayashi and Fumio Kawashima

1953. Study of tsutsugamushi. No. 32. New tsutsugamushi from birds from the vicinity of Hachijo. *Tokyo Iji Shinshi*, vol. 70, no. 4, pp. 15–17.

Sasa, Manabu, Shigeo Hayashi, Fumio Kawashima, Shingo Mitsutomi, and Masayoshi Egashira

1952. Study of tsutsugamushi. No. 20. Two new species collected from moles in Kyushu and Skikoku. *Tokyo Iji Shinshi*, vol. 69, no. 3, pp. 11–13.

Sasa, Manabu, Shigeo Hayashi, Nobuo Kumada, and Akiko Miura

1951. Study of tsutsugamushi. No. 6. On *Trombicula tenjin*, n. sp. in Japan. *Tokyo Iji Shinshi*, vol. 68, no. 3, pp. 17–18.

Sasa, Manabu, Shigeo Hayashi, Koji Sato, Akiko Miura, and Shozo Asahina

1950. Study of tsutsugamushi. No. 5. Chigger mites collected in the Mt. Fuji Area. *Tokyo Iji Shinshi*, vol. 67, no. 12, p. 14.

Sasa, Manabu, Shigeo Hayashi, Nobuo Kumada, and Seiyu Teramura

1950. Study of tsutsugamushi. No. 4. Chigger mites collected in the Mt. Fuji Area. *Tokyo Iji Shinshi*, vol. 67, no. 11, pp. 17–18.

Sasa, Manabu, and Rokuro Kano

1950. Study of tsutsugamushi. No. 1. *Trombicula wichmanni* discovered in Japan. *Tokyo Iji Shinshi*, vol. 67, no. 4, pp. 9–10.

Sasa, Manabu, Rokuro Kano, Nobuo Kumada, and Meiichi Ueda

1951. Study of tsutsugamushi. No. 14. The chigger mites in Hokkaido. *Tokyo Iji Shinshi*, vol. 68, no. 9, p. 9.

Sasa, Manabu, Rokuro Kano, and Takayuki Obata

1952. Study of tsutsugamushi. No. 28. On trombiculid mites collected from birds in the Tokyo Area. *Tokyo Iji Shinshi*, vol. 69, no. 10, pp. 13–15.

Sasa, Manabu and Fumio Kawashima

1951. Study of tsutsugamushi. No. 15. A new species found in Kochi Prefecture. *Tokyo Iji Shinshi*, vol. 68, no. 10, pp. 9–10.

1951a. Study of tsutsugamushi. No. 17. Two new species found in Kochi Prefecture. *Tokyo Iji Shinshi*, vol. 68, no. 12, pp. 15–17.

Sasa, Manabu, Fumio Kawashima, and Masayoshi Egashira

1952. Study of tsutsugamushi. No. 25. On *Trombicula (Miyatrombicula) kochiensis*, new subgenus, new species, from western Japan. *Tokyo Iji Shinshi*, vol. 69, no. 6, pp. 5–6.

Sasa, Manabu, Fumio Kawashima, and Seiichiro Hiromatsu

1952. Study of tsutsugamushi. No. 18. A new species collected from a mole in Kochi Prefecture. *Tokyo Iji Shinshi*, vol. 69, no. 1, p. 43.

Sasa, Manabu, Nobuo Kumada, and Akiko Miura

1951. Study of tsutsugamushi. No. 12. On the genus *Euschöngastia*. *Tokyo Iji Shinshi*, vol. 68, no. 8. p. 19.

Sasa, Manabu, Nobuo Kumada, and Seiyu Teramura

1951. Study of tsutsugamushi. No. 13. New species collected in Niigata and Akita Prefectures. *Tokyo Iji Shinshi*, vol. 68, no. 9, pp. 8–9.

Sasa, Manabu, Nobuo Kumada, Shigeo Hayashi, Yoshibumi Enomoto, Sadakichi Fukuzuki, and Yoshio Obata

1951. A new larval mite, *Trombicula himizu*, n. sp. from Japan. *Eisei Doobutsu*, vol. 2, no. 1, pp. 1–5.

Sasa, Manabu, Toshisada Sawada, Rokuro Kano, Shigeo Hayashi, and Nobuo Kumada

1951. Study of tsutsugamushi. No. 7. Two new species collected in Gumma Prefecture. *Tokyo Iji Shinshi*, vol. 68, no. 4, pp. 7–8.

Sasa, Manabu and Seiyu Teramura

1951. Study of tsutsugamushi. No. 8. A new species of *Walchia*, previously unrecorded from Japan. *Tokyo Iji Shinshi*, vol. 68, no. 5, p. 10.

Sasa, Manabu, Seiyu Teramura, and Rokuro Kano

1950. Study of tsutsugamushi. No. 2. Chigger mites from Hachijo Island. *Tokyo Iji Shinshi*, vol. 67, no. 10, pp. 22–23.

Schluger, E. G.

1948. New red mites (Acari, Trombidiidae) of the fauna of the U.S.S.R. *Entomologicheskoe Obozrenie*, t. 30, nos. 1 and 2, pp. 157–164.

Tanaka, Keisuke, J. Kaiwa, S. Teramura, and I. Kagaya

1930. Beiträge zur japanischen Kedani-Krankheit. *Zentralblatt für Bakteriologie*, Bd. 116, pp. 353–385.

Wharton, G. W.

1945. Two new species of Acariscus: *A. pluvius* and *A. anous* (Acarinida: Trombiculidae). *Journal of Parasitology*, vol. 31, no. 6, pp. 401–405.

Wharton, G. W. and A. B. Hardcastle

1946. The genus Neoschöngastia (Acarinida: Trombiculidae) in the western Pacific area. *Journal of Parasitology*, vol. 32, no. 3, pp. 286–322.

Womersley, H.

1952. The scrub-typhus and scrub-itch mites (*Trombiculidae*, Acarina) of the Asiatic-Pacific Region. *Records of the South Australia Museum*, vol. 10, pt. 1 (text), 435 pp., pt. 2 (plates), pp. 438–673.

PROCEEDINGS

OF THE

CALIFORNIA ACADEMY OF SCIENCES

Fourth Series

Vol. XXVIII, No. 6, pp. 323–337, figs. 1–5 July 9, 1954

FURTHER STUDIES OF THE BEHAVIOR OF THE PACIFIC SARDINE (SARDINOPS CAERULEA) IN AN ELECTRICAL FIELD

BY

ANATOLE S. LOUKASHKIN and NORMAN GRANT
California Academy of Sciences

The first stage of experimental studies on galvanotropic responses of the Pacific sardine (*Sardinops caerulea*), using pulsating direct current of low frequencies and a triangular wave form, was described by Groody, Loukashkin, and Grant (1952). That account was concluded (pages 317–322) by a study of the effects of the three variables involved, namely, maximum current density, ratio of current-on to current-off periods, and frequency of pulsation. During this experiment, 900 tests were made.

METHODS

The experimental tank and electrical design used in the present study are shown in figure 1 (after Groody, *et al.*, 1952, p. 312).

The following definitions, adopted in the earlier report (*op. cit.*), were used.

Perfect. When all four fish responded readily to each reversal of the poles and displayed a directional reaction toward the positive pole.

Good. When three of the four fish displayed the reaction given above or when all four fish failed to respond to one of the three reversals of poles.

Fair. When two of the fish readily responded to all pole reversals, or when all fish responded to at least one reversal.

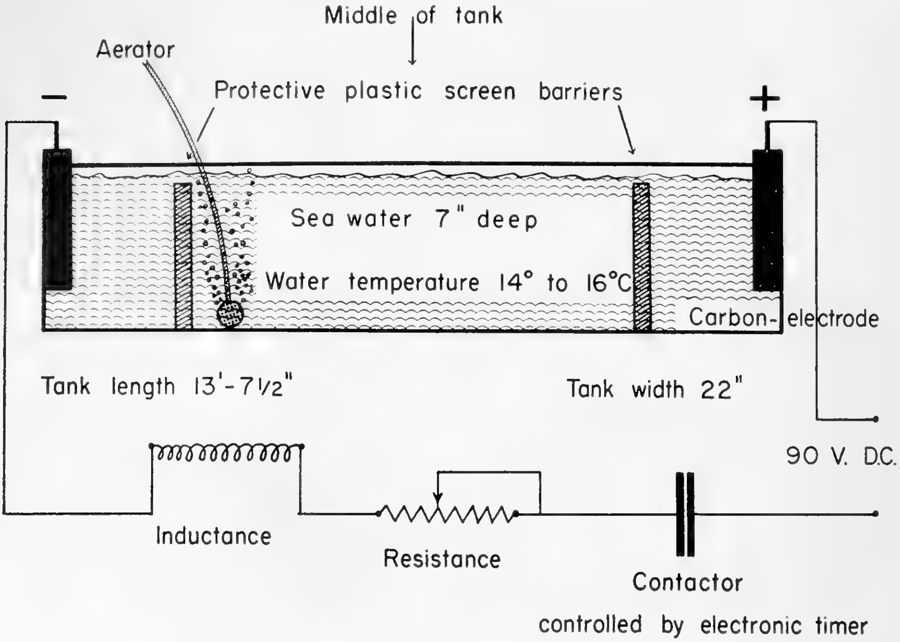


Figure 1. Diagram of experimental wooden tank and electrical circuit for triangular wave form of pulsating direct current. Reversing switch not shown (after Groody, Loukashkin, and Grant, 1952).

None. When one or none of the fish displayed directional reactions.

The first two grades were classified as *satisfactory* and the last two grades as *unsatisfactory* (table 1).

In addition to the above definitions for recording behavior, records were made of the fishes' response to the current relative to fright reactions to stimuli and to apparent control of their own swimming movements. For these records, the following symbols were used:

(—). Swimming movements apparently under control of the fish, no directional response, and all reactions to fright stimuli retained.

(½+). The avoidance reaction to the barrier was retained, but the fish did not respond to vibrations of the tank with fright reactions.

(+). Directional responses apparently controlled by electrical current density only. Normal fright reactions to the barrier or to other stimuli completely lost.

(+ +). In addition to the reactions above under (+), the fish remained in contact with the protective screen next the positive pole as

TABLE 1

Sardine reactions to variations in maximum current density of the square wave form direct current pulsating at low frequencies. (180 observations for each of the five densities tested.)

Maximum current density in milliamperes	*Directional swimming Results in per cent*							*Control of movements Results in per cent*						
	Unsatisfactory			*Satisfactory*				*Unsatisfactory*			*Satisfactory*			
	None	*Fair*	*Both*	*Good*	*Perfect*	*Both*	*Total*	(—)	(½+)	*Both*	(+)	(++)	*Both*	*Total*
10	35.5	40.0	75.5	19.0	5.5	24.5	100.0	53.3	44.5	97.8	2.2	0	2.2	100.0
15	25.6	41.1	66.7	25.5	7.8	33.3	100.0	35.5	37.8	73.3	24.4	2.3	26.7	100.0
20	14.4	27.8	42.2	37.8	20.0	57.8	100.0	21.1	15.6	36.7	41.1	22.2	63.3	100.0
25	20.0	27.8	47.8	24.4	27.8	52.2	100.0	16.7	11.1	27.8	30.0	42.2	72.2	100.0
30	11.1	17.8	28.9	33.3	37.8	71.1	100.0	8.9	13.3	22.2	15.6	62.2	77.8	100.0

TABLE 2

Sardine reactions to variations in ratio of current-on to current-off periods of the square wave direct current pulsating at low frequencies. (180 observations for each of the five ratios tested.)

Ratio of "on" to "off" periods	*Directional swimming Results in per cent*							*Control of movements Results in per cent*						
	Unsatisfactory			*Satisfactory*				*Unsatisfactory*			*Satisfactory*			
	None	*Fair*	*Both*	*Good*	*Perfect*	*Both*	*Total*	(—)	(½+)	*Both*	(+)	(++)	*Both*	*Total*
1 : 3	60.0	34.4	94.4	4.4	1.2	5.6	100.0	65.6	21.1	86.7	10.0	3.3	13.3	100.0
1 : 2	27.8	43.3	71.1	20.0	8.9	28.9	100.0	38.9	26.7	65.6	20.0	14.4	34.4	100.0
1 : 1	11.1	35.6	46.7	43.3	10.0	53.3	100.0	20.0	22.2	42.2	31.1	26.7	57.8	100.0
2 : 1	4.4	30.0	34.4	35.6	30.0	65.6	100.0	4.4	33.3	37.7	30.0	32.3	62.3	100.0
3 : 1	3.3	11.1	14.4	33.3	52.3	85.6	100.0	6.6	19.0	25.6	22.2	52.2	74.4	100.0

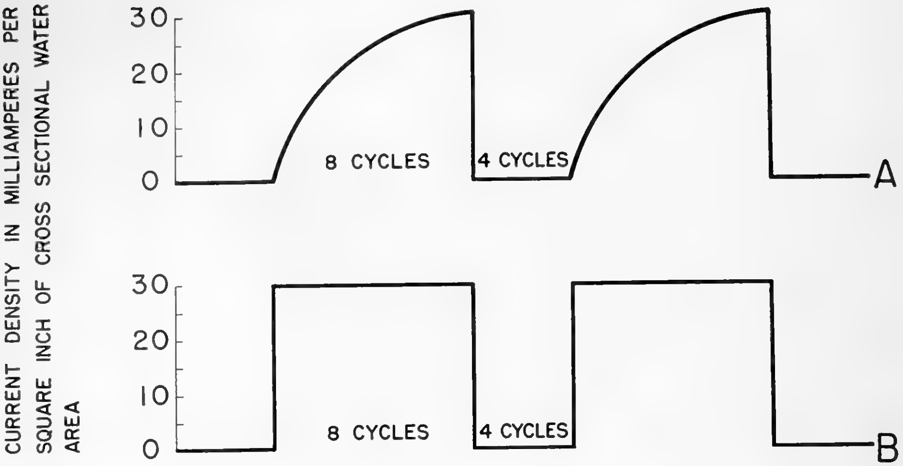


Figure 2. Triangular and square wave forms of direct current pulsating at low frequencies with a pulse of 30 milliamperes of maximum current density and an "on" to "off" ratio of 2:1. The frequency of pulsation is 5 per second. Timing base is 60 cycles per second.

long as the current was on. This was, of course, the most pronounced reaction to the current short of stunning and death.

(—) and (½+) were classified as *unsatisfactory,* (+) and (++) as *satisfactory* (table 2).

RESULTS

The present studies centered on the stimulating effects on sardine behavior of: (1) the square wave form of direct current pulsating at low frequencies; (2) application of higher frequencies of pulsating direct current using triangular and square wave forms; (3) application of half-wave rectified 60-cycle alternating current; (4) application of quarter-wave rectified 60-cycle alternating current; and (5) application of the condenser discharge impulse.

(1) *Effects of the square wave form of direct current pulsating at low frequencies.* Using the same facilities and equipment and following the same procedure and recording as described in the preliminary report cited above, a series of 900 analogous tests were made in order to investigate the effects of the square wave form of direct current pulsating at low frequencies.

The square wave impulse was obtained by omitting an inductance from the circuit diagrammed in figure 1. Contrary to the triangular

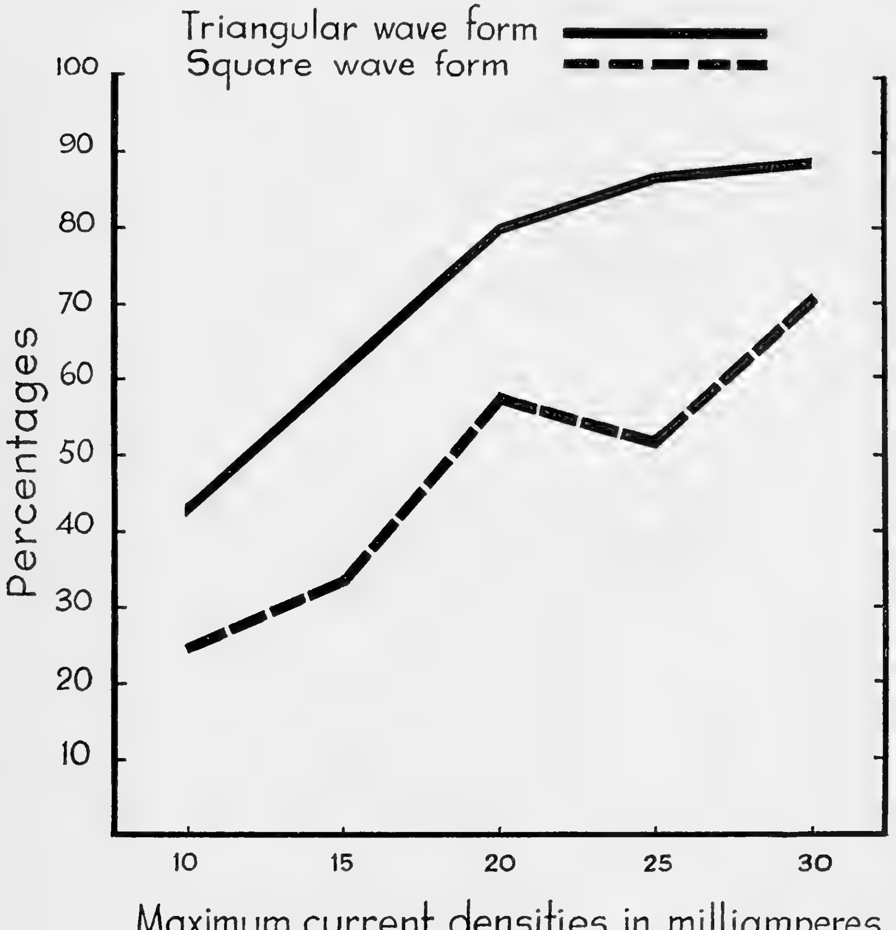


Figure 3. "Satisfactory" directional reactions (in per cent) of the sardines in an electrical field produced by using triangular and square wave forms of direct current pulsating at low frequencies. Percentages are based on 180 observations for each of the five maximum current densities of each wave form tested.

wave form, the square wave impulse rises instantly to its maximum, maintains this density for the desired period and then, like the triangular wave, it returns abruptly to zero (figure 2). The results of these tests are shown in tables 1 and 2.

The tests indicate that current density is the most critical factor. When the maximum current density increases from 10 to 30 milliamperes per square inch of cross-sectional area of water, there is a well-displayed trend toward increase of "satisfactory" results. As is shown in figures 2 and 3, this is true of both wave forms but is more marked in the triangular wave.

A comparative analysis of the results obtained indicates that the triangular wave form produced comparatively better directional responses than did the square wave, while "satisfactory" control of fish movements was obtained more frequently with the square wave. However, the difference does not appear to be significant. It can be concluded that both wave forms of direct current pulsating at low frequencies* are "satisfactory" in producing a directional response and in control of the sardine movements.

(2) *The application of higher frequencies of pulsating direct current using triangular and square wave forms.* In order to obtain pulsating direct current of the higher frequencies, a high-speed mechanical interrupter was introduced into the circuit diagrammed in figure 1. Using both types of current wave forms and applying a 1:1 ratio of current-on to current-off periods (figure 5: A and B), the following frequencies were tested: 5, 20, 35, 50, 65, and 80 per second.

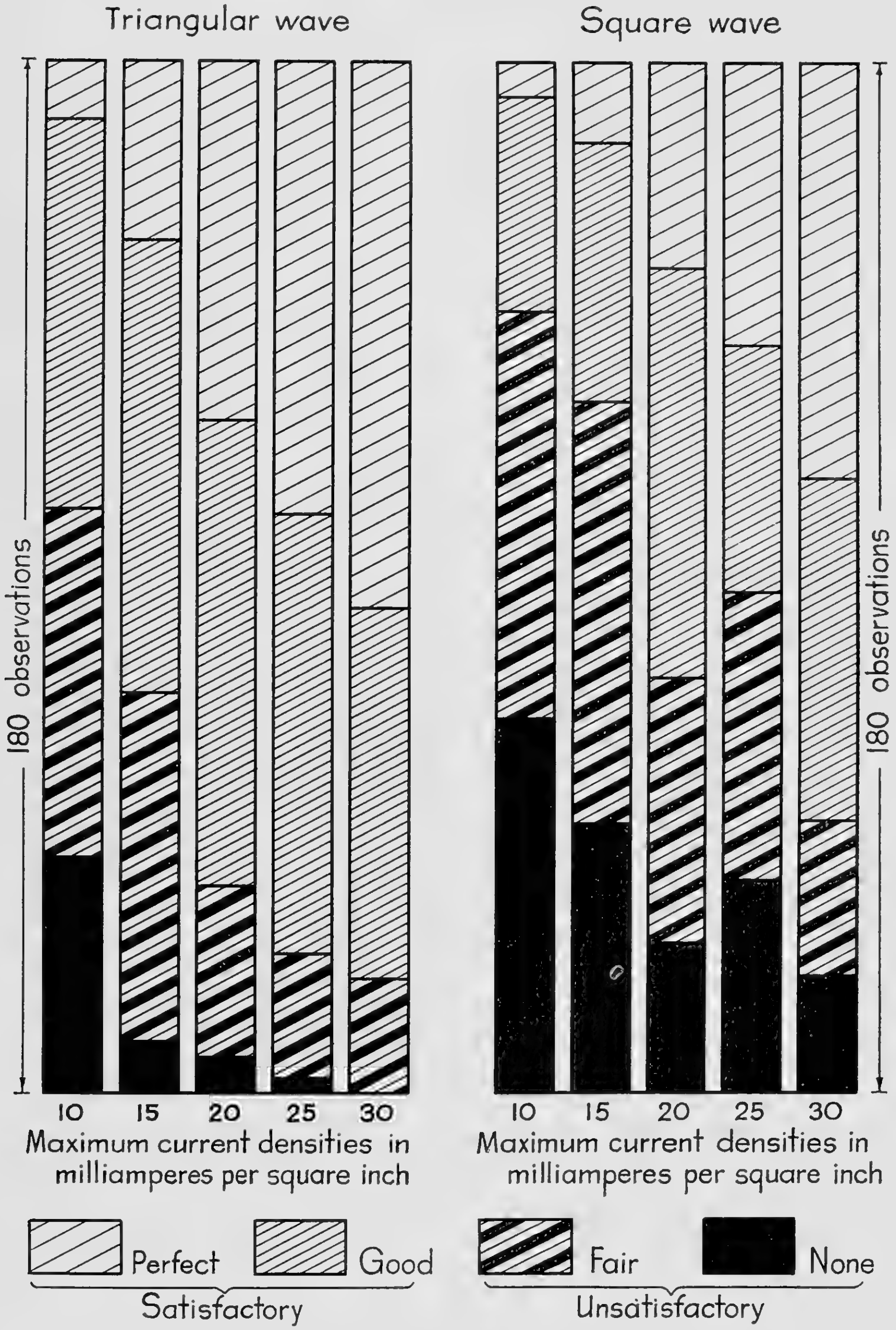
The experiments disclosed that the *average current density* of pulsating direct current is a more important factor in producing directional swimming and control of fish movement than the *maximum or peak current density.* Also, it was found more convenient to express current density as an average value since this can be read directly from the ammeter dial. This average value is dependent on the ratio of the "on" to "off" periods.** For example, using a square wave form and an "on" to "off" ratio of 1:1, the average current density would be one half of the maximum or peak current value attained during the "on" period. Applying the same value of the maximum current density and changing the "on" to "off" ratio from 1:1 to 2:1 and 1:2, the average current density will be higher when a 2:1 ratio is used, lower when a 1:2 ratio is used. This statement differs from, but is not inconsistent

---

*The table of sardine reactions to variations in current pulsation frequency is omitted because the rate of current pulsation (within the range of 2, 4, and 6 times per second) seemed to have no significant effect on directional swimming and control of fish movements. This observation is in full accord with the records for the triangular wave form given in the preliminary report (Groody, *et al.*, 1952, table 2).

**When straight direct current (i.e., not pulsating) is used, the values of maximum and average current densities are equal.

Figure 4. Numbers of classified directional reactions of the sardines per current density tested using triangular and square wave forms of direct current pulsating at low frequencies. Each column for each maximum current density represents 180 observations.


Triangular wave
Square wave
180 observations
180 observations
10
15
20
25
30
10
15
20
25
30
Maximum current densities in milliamperes per square inch
Maximum current densities in milliamperes per square inch
Perfect
Good
Fair
None
Satisfactory
Unsatisfactory

with, that in our earlier paper (Groody, *et al.*, 1952, p. 318, and table 3). It was shown there that control of movement was increasingly successful with increasing ratio of current-on to current-off periods. It will be obvious that this result is satisfactorily explained as an increase in *average current density.*

Using a triangular or any other wave form and applying the same values of the maximum or peak current density and the same ratios of the "on" to "off" periods, the average current density would be always less than that of the square wave form.

Use of the higher frequencies in this experiment produced "perfect" directional swimming and full (+ +) control of fish movements at considerably reduced average current densities. The current density required to produce highly "satisfactory" results at a frequency of 65 to 80 pulses per second was only 50 per cent of that needed at a frequency of five pulses per second.

Optimal ranges of the average current density established by the above experiments for the Pacific sardine 200–300 mm. in standard length are shown in table 3.

TABLE 3

The Effect of Frequency of Pulsation Upon Optimal Average Current Density
(240 Observations)

Values of frequencies of pulsating direct current, using square or triangular wave forms and 1:1 ratio of current-on to current-off periods.	Values of the optimal average current densities which produce "perfect" directional swimming and full (+ +) control of fish movements.
5 times per second	From 8 to 12 milliamperes/sq. inch
20 " " "	" 8 to 10 " " "
35 " " "	" 6 to 8 " " "
50 " " "	" 6 to 8 " " "
65 " " "	" 4 to 6 " " "
80 " " "	" 4 to 6 " " "

(3) *The application of half-wave rectified 60-cycle alternating current.* As frequencies of pulsating direct current as high as 65 to 80 per second were found to be more effective than the low frequencies, in regard to reducing the amount of average current density required to produce directional swimming and control of fish movements, it was then decided to test the sardines in an electrical field of half-wave rectified 60-cycle alternating current, using a standard mercury vapor rectifier tube. This produces a rounded and evenly sloped current wave form with a 1:1 ratio of current-on to current-off (figure 5C).

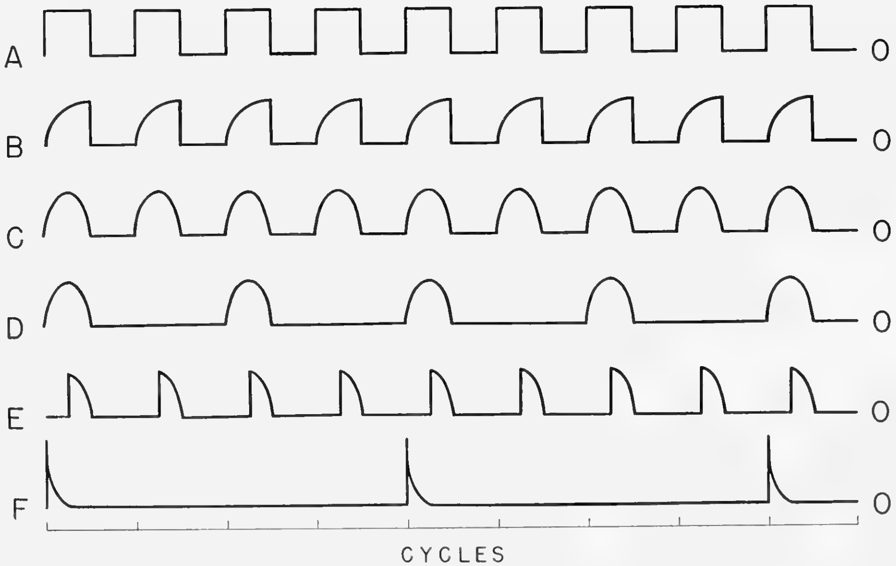


Figure 5. The wave forms of pulsating current with timing base of 60 cycles per second: A. The square wave form of direct current pulsating 60 times per second with an "on" to "off" ratio of 1:1; B. The triangular wave form of direct current pulsating 60 times per second with an "on" to "off" ratio of 1:1; C. The half-wave rectified 60-cycle alternating current; D. The same half-wave rectified 60-cycle alternating current interrupted 30 times a second; E. The quarter-wave rectified 60-cycle alternating current; F. Condenser discharge impulse at a frequency of 14 to 15 times per second.

Each cycle—1/60 of a second.

Using the facilities and equipment shown in figure 1 with the exception that the inductance and contactor were left out of the circuit, a series of more than 300 tests were made, using groups of four sardines 200–230 mm. in standard length, the procedure and recording being the same as in previous experiments.

From these experiments it was found that the optimal average current density required to produce "perfect" directional swimming and fully controlled fish movements varied within the range of 3.3 to 5.0 milliamperes per square inch of cross-sectional area of water. The higher average current densities from 6 to 9 milliamperes showed a tendency to stun the fish and it appears that this stunning effect is directly related to the increase in average current density.

Following the experiments with the sardines, topsmelt (*Atherinops affinis*), 100–110 mm. in standard length, were subjected in groups of four to the stimulation. They were found to respond in a similar manner to the sardines, the only difference being that the optimal average current density requirement was found to be almost twice as high (table 4). This is in accord with a statement made in the earlier study (Groody, *et al.*, 1952, p. 317) concerning the apparent inverse relationship between the amount of current density needed to produce directional swimming and the size of the fish. It should be pointed out, however, that these observations were made on different species of fish. Unfortunately, the species of fish used were available in only one size. Interestingly, McMillan (1929, p. 102), who studied the effect of voltage gradient required to produce paralysis on rainbow trout (*Salmo irideus*) and chinook salmon (*Oncorhynchus tschawytscha*) that varied in length from 1.87 to 12.50 and from 3.10 to 31.75 inches respectively, states ". . . the voltage gradient required to produce paralysis is inversely proportional to the length of the fish. In other words, the long fish require a much lower field strength to paralyze them than the short ones."

Further, to check this relationship between length of fish and current density required, jacksmelt (*Atherinopsis californiensis*) 300–330 mm. in standard length, were similarly tested in groups of four. This fish, too, reacted as did the sardines but the optimal average current density requirement was as low as 2.5 to 3 milliamperes per square inch of cross-sectional area of water. Higher current density caused the fish to roll over and remain stunned until the current was turned off.

In each of the three species tested with average current densities above the optimal range, fish have been stunned to various degrees but all recovered as soon as the current was turned off. When returned to their holding tanks, the fish rejoined schools and apparently suffered no ill effects from the experiments.

In the case of all three species of fish, the half-wave rectified 60-cycle alternating current caused a higher speed of swimming than the triangular or the square forms. Other observations indicated that, under the influence of the half-wave rectified A.C., the fish reacted with considerably more ease and showed less distress during forced swimming toward the positive pole. This is not easy to establish on a quantitative basis, but was a fact of observation that was confirmed by several observers.

Typical behavior of the fish in a field of half-wave rectified 60-cycle A.C. is summarized in table 4.

Table 4

Reactions and Optimal Average Current Densities Using Half-Wave Rectified 60-cycle Alternating Current

Species of Fish Stimulated	Standard Length of the Fish Tested in Millimeters	Optimal Range of the Average Current Density Required to Produce "Satisfactory" reactions as Described in the Lower Part of This Table
Pacific Sardine *Sardinops caerulea*	200 – 230	3.3 to 5 milliamperes
Topsmelt *Atherinops affinis*	100 – 110	7.0 to 9.0 "
Jacksmelt *Atherinopsis californiensis*	300 – 330	2.5 to 3.0 "

Description of fish behavior in an electrical field within the optimal range of the average current densities:

Orientation instantaneous and simultaneous. Directional swimming "perfect"; response to reversals of polarity immediate and coordinated. Control of movement full (+ +): fish cannot avoid barrier inserted between swimming fish and positive pole; all natural fright reactions to disturbing stimuli entirely lost; upon reaching protective screen (two feet in front of the positive electrode) fish cannot swim away, being strongly attracted toward the electrode. Swimming very rapid, sometimes performed as a rapid gliding over the water surface toward positive pole. Easy on fish.

This half-wave rectified 60-cycle alternating current was also interrupted 30 times a second by using a thyratron tube, and the wave form so obtained is shown in figure 5D.

The experiments carried out on the same three species of fish resulted in obtaining "perfect" directional swimming and fully controlled movement (+ +) of the fish as described above, however, the amount of the average current density required to produce these reactions was about one-half of that established for the pure (uninterrupted) half-wave rectified 60-cycle alternating current.

(4) *The application of the quarter-wave rectified 60-cycle alternating current.* For experiments using a wave form that starts with the maximum current and slopes gradually to zero as shown in figure 5E, the authors used a mercury vapor thyratron tube and phase-changing equipment. It is actually a quarter-wave impulse and the reverse of the originally tested triangular wave form of pulsating direct current.

Use of this quarter-wave form and the same optimal range of the average current densities and species of fish as in the experiments with half-wave rectified 60-cycle A.C. (table 4), resulted in fish reactions that were less satisfactory. In this experiment, over 200 tests were made.

Although the fish did orient and swim toward the positive pole, their direction of swimming being fully under electrical control, it was obvious that they experienced certain difficulties and attempted to escape from the field by raising their heads out of water and trying to jump over the sides of the tank. There were several cases of strong stunning effects, even when the lower values of the optimal range of the average current density were applied. It also required a longer period for the fish to relax and resume normal behavior after these tests than it did after any of the previous experiments. These effects were observed in the responses of each of the three species used.

It is assumed that in order to obtain an optimal range of the average densities established for the half-wave current, the magnitude of the wave peak must be much greater in the quarter-wave impulse than in the former. In all probability, this is the cause of a strong and lasting stunning effect observed on the fish tested.

(5) *The application of the condenser discharge impulse.* The present investigations of the effects of various wave forms and frequencies of pulsating direct current were completed by experiments with condenser discharge pulses having a frequency of approximately 14 per second. This was produced by charging a 50 MF condenser from a source of half-wave rectified 120-volt alternating current and discharging through a mercury vapor thyratron tube. The wave form thus obtained is diagrammed in figure 5F.

A series of more than 300 tests showed that this type of current impulse was also effective in producing directional swimming of the sardine. The optimal range of the average current densities was found to be as low as 0.4 to 0.8 milliampere per square inch of cross-sectional area of water.* It is evident from these tests that the amount of electrical

---

*The negative results of the effects of the condenser discharge mentioned in the preliminary report (Groody, *et al.*, 1952) were probably due to the discharge of condenser through mechanical contactor instead of the thyratron tube.

energy required to produce directional swimming of the sardine is much less using condenser discharge than by employing other wave forms tested.

When optimal average current densities were used the sardines' reactions showed that while forced directional swimming was clearly displayed, the fish experienced considerable difficulty in reorienting when the polarity of the electrical field was reversed. They usually continued swimming in the original direction for a short distance. It was observed that while they were attempting to turn, their bodies vibrated at what appeared to be the pulse frequency. It also appeared that this type of current impulse caused the fish to become exhausted in a short time: they were easily picked up by hand for transferring in a bucket back to their holding tank.

Similar effects were observed with jacksmelt. Their optimal range was found to be between 0.4 to 0.6 milliampere per square inch. No topsmelt were available at the time of the experiments.

Although controlled directional swimming was clearly displayed, the full control of fish movements (+ +) was not immediately obtained: both the sardine and jacksmelt were able to leave the positive pole and swim away toward the negative pole; however, after several such escaping attempts the fish finally returned to the positive pole.

Application of the higher values of the average current density above optimal range in order to produce an immediate and full control of the fish movements resulted in a strong stunning effect on the fish as soon as the current was turned on. One of the sardines used in these tests became totally blind, and it died 12 hours later.

The saving in current obtained by the use of condenser discharge is particularly significant in view of the fact that one of the most important problems in the development of electrofishing is the large amount of power needed to establish suitable current densities in sea water.

Discussion

Observations made during the course of experimental studies of the behavior of the Pacific sardine carried on in the California Academy of Sciences since 1950, have established that this species is highly susceptible to stimulation by electrical currents. The fish usually begin to feel the presence of an electrical field even when the lowest values of average current density are applied.

The sensitivity of the sardine to changes in average current density and the degree of stimulating effect that has been once established for each density value remain constant. This is true for each particular type of pulsating current tested. As soon as the optimal range of average current density required to produce directional swimming and control of fish movement has been found, the sardine's reactions will always remain identical regardless of the number of times the tests are repeated or the sequence of the tests.

The observations present another fact, namely, the sardines just captured or the ones that have been kept in captivity for an extended period of time display identical sensitivity as described above. No conditioning has ever been observed despite the fact that the experimental fish were confined in the Steinhart Aquarium's holding tanks for more than two and one-half years and were used twice a week on the average in electrical stimulation experiments. In contrast to the topsmelt and jacksmelt, their peculiar reactions to each particular value of the average current density applied, have been invariably the same. Topsmelt and jacksmelt usually became conditioned after 5–10 successive stimulations, and therefore in the experiments here reported these fishes have often been replaced by the fresh specimens not previously subjected to the electrical field.

The results of the effects of various wave forms and currents and of different frequencies recorded during the course of experimental studies have been checked many times. These repeated tests have proved that the optimal ranges of average current density experimentally determined for the three species of fish for each different type of electrical current, have always remained essentially the same.

The observations also indicate that, when a proper value of average current density is applied and the fish movements are fully (+ +) controlled, their natural fright reactions to disturbing stimuli are entirely suppressed and the fish can be easily picked up by hand. This observation applies to all three species used in the present investigations.

CONCLUSIONS

1. The five types of pulsating direct current wave forms used by the experimenters are effective in producing forced directional swimming of the Pacific sardine (*Sardinops caerulea*) and also the jacksmelt (*Atherinopsis californiensis*), and the topsmelt (*Atherinops affinis*) that were used as controls.

2. All wave forms tested can produce full (+ +) control of fish movements and force them to the positive pole where they can be held until the current is turned off.

3. The electrically stimulated reactions can be obtained and will remain constant if a proper optimal range of average current density is determined for each particular species and size.

4. Current density is the most critical factor in producing forced directional swimming and control of fish movements.

5. Average current densities above the optimal range may cause temporary paralysis or even death of the fish whereas those below produce a slight directional response or none at all.

6. The optimal average current density required to produce "satisfactory" directional swimming and controlled (+ +) movement of fish appears to vary inversely with the size of the fish.

7. Full control of fish movement and forced directional swimming can be obtained with any frequency of current pulsation from 2 to 80 per second; the frequencies above 80, however, have not been tested.

8. The use of a pulse frequency as high as 60 to 80 per second reduced the optimal average current density to 50 per cent of the amount required at a frequency of 5 per second.

9. The most effective and "satisfactory" results, as far as the smoothness of performance and school coordination are concerned, were recorded when either continuous or interrupted half-wave rectified 60-cycle alternating current was used.

10. Condenser discharge pulse produced the "satisfactory" reactions at very low average current densities (0.4 to 0.8 milliampere). This represents a substantial decrease in power requirements.

Acknowledgments

This work has been carried on with funds provided by the Marine Research Committee as a part of the California Cooperative Oceanic Fisheries Investigations. The authors express their appreciation to Dr. Robert C. Miller, director of the California Academy of Sciences, for his keen interest in the studies and for encouragement and valuable suggestions during the progress of the research; and to Dr. Earl S. Herald, curator of aquatic biology, California Academy of Sciences, for his willing cooperation and valuable counsel. Acknowledgment is made also to Drs. Roger Revelle and Carl L. Hubbs, of the Scripps Institution of Oceanography; Dr. Francis N. Clark, director of the California State Fisheries Laboratory, and Mr. John C. Marr and Dr. E. H. Ahlstrom, of the U. S. South Pacific Fisheries Investigations, for helpful suggestions and constructive criticism of the manuscript.

LITERATURE CITED

Groody, Tom, Anatole Loukashkin, and Norman Grant

1952. A preliminary report on the behavior of the Pacific Sardine (*Sardinops caerulea*) in an electrical field. Proceedings of the California Academy of Sciences, vol. XXVII, no. 8, pp. 311–323, 4 text figures.

McMillan, F. O.

1929. Electric fish screen. Bulletin of the United States Bureau of Fisheries, vol. XLIV (1928), pp. 97–128, 21 text figures.

PROCEEDINGS
OF THE
CALIFORNIA ACADEMY OF SCIENCES

Fourth Series

Vol. XXVIII, No. 7, pp. 339-353, figs. 1-3 June 30, 1955

ON THE PACIFIC SARDINE (*SARDINOPS CAERULEA* GIRARD) IN AQUARIA: TRANSPORTATION, HANDLING, MAINTENANCE, AND SURVIVAL

BY

ANATOLE S. LOUKASHKIN and THOMAS C. GROODY
California Academy of Sciences

INTRODUCTION

The behavior of marine fishes under laboratory conditions, particularly that of members of the Clupeoidea, has been very little studied. Parr (1927) offers this explanation: "It is most unfortunate that the species showing the schooling performances most clearly, as for instance herrings, spratts, and mackerels, usually are of such delicate nature that it is practically impossible to keep them alive for any length of time." Further reference to the subject is made by Spooner (1931) who states: "Choice of schooling fish suitable for observation in captivity is limited to a very few species. Small mackerel, herring, and spratt are excluded on account of difficulties involved in keeping them in confinement."

A number of behavior studies under laboratory and field conditions have been made, however, on various species of herrings (Newman, 1876; Shelford and Powers, 1915; Powers, 1921; Breder, 1929), and on several unrelated marine fishes, including the great blue shark *Prionace glauca* (Hubbs, 1948), and the tarpon *Tarpon atlanticus* (Shlaifer and Breder, 1940; Shlaifer, 1941).

Papers on the Pacific sardine *Sardinops caerulea* (Girard) have been confined largely to scattered field observations by Cornish (1883) and Allen (1920, 1930).

---

*Submitted February 10, 1953.

Fishes of the suborder Clupeoidea are anatomically, physiologically, and temperamentally among the most delicate of marine fishes. This is especially true of the Pacific sardine, whose nervous temperament, so familiar to men engaged in the sardine fishery, renders it a difficult subject for laboratory study. The ease with which the sardine is injured through handling, coupled with its sensitivity to environmental changes in salinity, temperature, and oxygen may well account for the absence of laboratory studies on this economically important fish.

Since these fishes rank among the most important from the standpoint of the world's economy and resources, it was deemed necessary to establish the conditions under which they should be transported to a laboratory and there maintained as objects for detailed experimental investigations.

METHODS OF HANDLING

Transportation:

Altogether, seven shipments of live adult sardines, totalling 751 specimens, were delivered to the Steinhart Aquarium during 1949–51. The first three lots, purchased from bait-fishermen, came from Monterey Bay.

The first lot of 57 sardines was delivered May 19, 1949. All the fish died off rapidly. The second lot of 37 sardines was delivered August 4, 1949. By the next day 27 fish (73 per cent) had died; the rest of the fish survived a few days. The third shipment of 24 sardines was made on December 22, 1949. Heavy casualties were incurred in the first 48 hours after delivery; however, five fish survived until the end of May, 1950.

This excessive mortality among the sardines from Monterey Bay was considered to be due to the long travel time (about three hours) in the collecting truck; so all subsequent collections were brought to San Francisco from the Los Angeles area aboard the M.S. *Yellowfin,* research vessel of the California Department of Fish and Game.

The sardines from the Los Angeles area were also purchased from bait-fishermen and were kept in the wooden bait-tank of the *Yellowfin,* which tank contained 1,125 gallons of circulating sea-water. The vessel's voyage between Los Angeles and San Francisco was usually made in 50–52 hours, and sometimes the ship experienced rough weather. Delivery to the Academy's Steinhart Aquarium from aboard ship, a distance of eight miles, was made in a collecting truck equipped with 45- and 100-gallon cans (fig. 1) that have air compressors and inside lights. Two or three truck trips, each of which took from 15 to 40 minutes, were required to unload each shipment. Dip-nets and two-gallon buckets were used for transferring the sardines, both at the dock and the Aquarium.

The fourth shipment of 128 sardines, from Long Beach, was delivered on June 9, 1950. In 96 hours after delivery, 85 sardines (66.5 per cent)

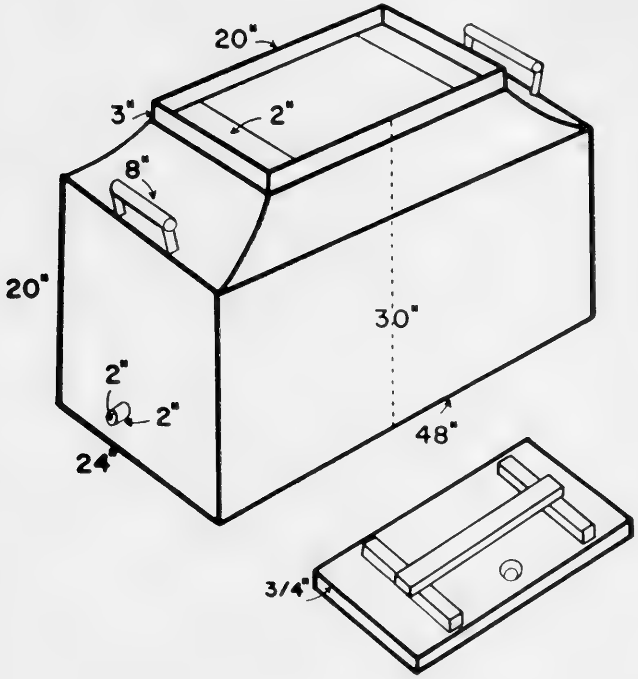


Figure 1. Drawing of a 100-gallon transporting can.

had died; by the end of the third week only 13 fish survived. The fifth shipment of 114 sardines, from Los Angeles harbor, was delivered on October 4, 1950. In 96 hours of confinement in the Aquarium's holding tanks, 54 (47.4 per cent) sardines died off; by the end of the third week the cumulative mortality was 84.2 per cent. On the sixty-second day of captivity only 16 fish survived. The sixth shipment of 116 sardines, from Los Angeles harbor, was received on December 3, 1950. In a 96-hour period 42.2 per cent of the fish died off; at the end of the third week the cumulative mortality was 67.2 per cent. Toward the end of October, 1951 (13 months after delivery), 32 sardines were still living. The seventh shipment of 275 sardines, from Los Angeles harbor, was delivered on October 22, 1951. In a 96-hour period only 38.9 per cent died; at the end of the third week the cumulative mortality was only 42.9 per cent. A count made on January 8, 1953 (14 months and 17 days after delivery), revealed that 43 sardines successfully survived, together with 10 fishes of the sixth shipment.

Maintenance:

At the Steinhart Aquarium, the experimental fish were confined in holding tanks having a capacity of about 1,000 gallons (table I) which, as our experience indicates, were adequate for about 50 adult fish. The Aquarium salt water is pumped from the ocean to a storage tank and the rate of flow through the 1,000-gallon holding tanks is 86 gallons per hour. Each tank is aërated but in most cases temperature and *p*H are not controlled. In most tanks, the temperature range was 11.0–20.5°C. and that of the *p*H, 7.0–8.0.

DEGREE OF SURVIVAL

In transit:

Data on mortality during the sea voyage to San Francisco from Los Angeles were not recorded in the ship's log of the *Yellowfin*. However, according to John Radovich *(in lit.)*, "sardines have been kept alive for an entire cruise on several occasions with a very small loss in the vessel's bait-tank."

From our observations it is readily apparent that sardines of the first load removed from the vessel's bait-tank and transferred to holding tanks of the Aquarium, as a rule, incur heaviest losses during the first three-week period in comparison with those of the other loads of the same shipment that were transferred later. This is especially true of the seventh shipment of October 22, 1951, when 275 sardines were transported in three consecutive truck trips, and distributed in three separate holding tanks at the Aquarium. A very accurate record of mortality was kept, and a summary is presented in table II.

TABLE I

Data on Holding Tanks in Steinhart Aquarium

Capacity	1057 gallons
Inside dimensions	74″ x 75″ x 44″
Operating water volume	1,000 gallons
Rate of water turnover	86 gal./hr.
Air introduced by suction through opening in water inlet tube	variable rate
Annual temperature range for tank with non-regulated water temperature	11.0°C. to 20.5°C.
Greatest temperature fluctuation in 24 hours	1°C.

Observation indicates that fish of the first load are those which have suffered most during the voyage or from previous handling by the bait-fishermen. They usually swim about close to the surface in the ship's bait-tank and are the first to be netted out for transportation, while healthy fish dive to the bottom of the tank and stay there until netted.

TABLE II

Mortality among sardines of various loads transported in a truck from the Yellowfin *bait-tank to the Steinhart Aquarium holding tanks on October 22, 1951. Shipment consisted of 275 adult sardines.*

Tank number	*Load number*	*Number of fish delivered*	*Number of fish died off*	*Length of mortality period in days*	*Percentage of mortality*		*Remarks*
					Total	*Average daily for mortality period*	
2	1	136	80	6	58.8%	9.8%	No mortality after 6th day until end of 3-week period.
42	2	47					
	3	65					
		112	28	10	25.0%	2.5%	One more fish died between 11th day and end of 3-week period.
41	3	27	5	8	18.5%	2.3%	No mortality after 8th day until end of 3-week period.

Improvements in methods of handling and transporting the fish, such as less crowding and water movement in the truck's transporting cans and the use of artificial light, lowered the mortality significantly (table III and fig. 3). The last three shipments showed a drop in mortality from 84.2 per cent to 42.9 per cent.

In the Aquarium:

The high mortality, as a rule, occurs during the first three weeks of confinement in the Aquarium. In large measure, it reflects the effect of transportation from aboard ship to the Aquarium. In regard to fish survival, these three weeks are considered as a critical period. As our records show, at the end of the first three weeks mortality in the Aquarium holding tanks due to transporting and handling was zero.

Closely comparable results were obtained by Janssen and Alpin (1945). They state that mortality attributable to catching and handling among the sardines kept in floating boxes for tagging experiments was high for about the first six days of confinement (about 55 per cent for the control fish, and 70–75 per cent for the tagged fish). Similarly, after 20 days of confinement there were few deaths.

During the 44-month period, out of the 751 sardines delivered to the Aquarium, 520 fish or 69.2 per cent died during the first three weeks of captivity in the Aquarium. Approximately 178 fish (23.7) per cent from which groups of specimens were drawn for experimental purposes, died thereafter because of accidents, starvation, or other causes of natural mortality, while 53 fish (7.1 per cent) were still living on January 8, 1953 (table VI).

It is shown in table V that only about 44 per cent of the mortality can be attributed to natural causes. Following the critical period, the mortality rate is exceedingly low. For example, of the last or seventh shipment of 275 sardines, 157 survived the critical three-week period after which mortalities were observed on the average (n = 9) at intervals of only 57 days (interval range, 4–109 days). In one instance, 10 sardines survived 768 days but appeared to be starved or suffering from a pathological condition at the end of the experiment.

TABLE III

RECORDS OF SARDINE MORTALITY DURING THE FIRST THREE WEEKS OF CONFINEMENT IN THE STEINHART AQUARIUM'S HOLDING TANKS ATTRIBUTABLE TO TRANSPORTING AND HANDLING*

Last Three Shipments Transported from Los Angeles to San Francisco Aboard the "Yellowfin"

	114 fish delivered on Oct. 4, 1950		*116 fish delivered on Dec. 3, 1950*		*275 fish delivered on Oct. 22, 1951*	
Day	*Daily loss*	*Cumulative percentage*	*Daily loss*	*Cumulative percentage*	*Daily loss*	*Cumulative percentage*
1st	4	3.5	2	1.7	43	15.6
2nd	14	15.8	21	20.0	55	35.6
3rd	20	33.3	18	35.3	8	38.5
4th	16	47.4	8	42.2	1	38.9
5th	12	58.1	13	53.5	1	39.3
6th	10	66.6	7	60.0	1	39.6
7th	6	71.9	5	63.8	3	40.7
8th	4	75.4	2	65.5	2	41.4
9th	3	78.1	1	66.4	2	42.2
10th	3	80.7	0	66.4	1	42.6
11th	2	82.5	1	67.2	0	42.6
12th	1	83.3	0	67.2	0	42.6
13th	1	84.2	0	67.2	0	42.6
14th	0	84.2	0	67.2	0	42.6
15th	0	84.2	0	67.2	0	42.6
16th	0	84.2	0	67.2	0	42.6
17th	0	84.2	0	67.2	1	42.9
18th	0	84.2	0	67.2	0	42.9
19th	0	84.2	0	67.2	0	42.9
20th	0	84.2	0	67.2	0	42.9
21st	0	84.2	0	67.2	0	42.9
Mortality	96	84.2	78	67.2	118	42.9
Survival	18	15.8	38	32.8	157	57.1
Total	114	100.0	116	100.0	275	100.0

*The first shipment from the Los Angeles area which incurred 90 per cent loss at the end of the first three weeks is not included due to incomplete daily recording.

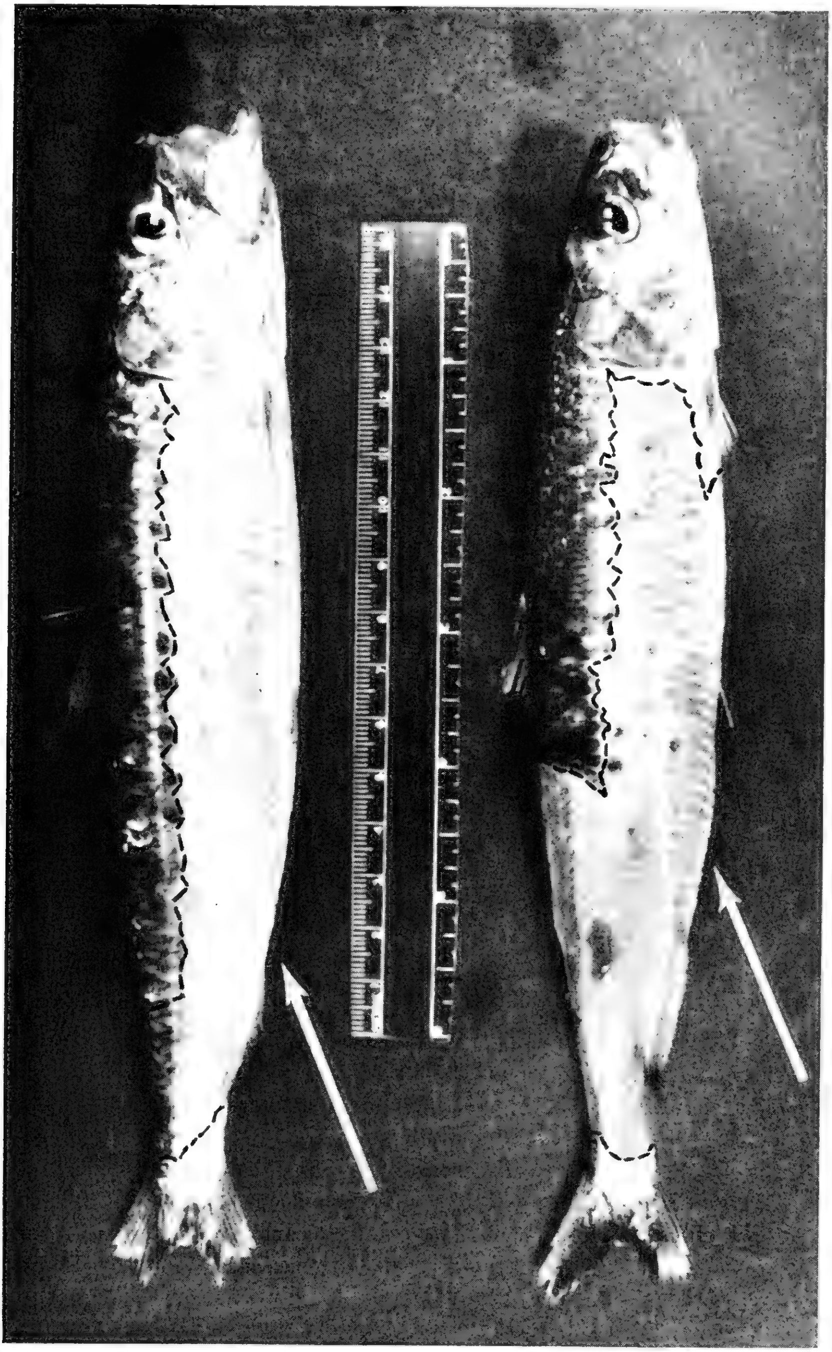


Figure 2. Showing extreme examples of external injury attributable to transporting.

TABLE IV

MORTALITY AND SURVIVAL AMONG SARDINES IN HOLDING TANKS OF THE STEINHART AQUARIUM

Ship-ment No.	*Date of delivery*	*Number of fish*	*Mortality due to transporting during first 3 Weeks*		*Survival of fish of:*			*Remarks*
			Number	*Per Cent*	*Latest shipment (number)*	*Previous shipment (number)*	*Total live fish (number)*	
1	2	3	4	5	6	7	8	9
1	May 19, 1949	57	57	100.0	0	0	0	
2	August 4, 1949	37	37	100.0	0	0	0	*26 of the 6th shipment and 4 of the 5th.
3	December 22, 1949	24	19	80.0	5	0	5	
4	June 9, 1950	128	115	90.0	13	5	18	
5	October 4, 1950	114	96	84.2	18	10	28	
6	December 3, 1950	116	78	67.2	38	26	64	
7	October 22, 1951	275	118	42.9	157	30*	187	
	Total	751	520	69.2	—	—	—	

Factors Causing Mortality

In Transit:

Examination of the dead fish immediately following delivery has indicated that all of them had lost most of their scales, in some instances, 90 per cent (fig. 2). The first fish to die were those with head or abdominal injuries causing internal hemorrhages of the brain, heart region, or intestinal tract. Fish with badly damaged snout areas and fins survive a little longer, while those with pinpoint subcutaneous hemorrhages over the entire body may live much longer. Fish in the last category with scales intact may even recover and survive the three-week critical period.

When a ship carrying sardines in her bait-tank is preparing to enter a harbor which is fed by fresh water, extreme care should be taken in regard to the time of entrance. From sad experience we know that the rate of mortality is high when the salinity is markedly reduced by the circulation of brackish water through the vessel's bait-tank.

To avoid mortality due to changes in salinity or to pollution, sardine-carrying vessels should enter port at the beginning of flood tide and unload before the ebb. Also, transporting cans to carry the sardines from the docked vessels should contain a fresh supply of sea-water for each truck trip. This is necessary not only because of the salinity factor, but also because of the copious slime secretion and scale shedding, both of which interfere with normal respiration of the fish.

Uninterrupted aëration and a temperature differential not exceeding 3°C. when fish are moved from a vessel to the Aquarium must be maintained to reduce mortality. Also, the use of dip-nets in handling the fish was discouraged in favor of two-gallon buckets with a maximum of four sardines per bucket.

Both external and internal body injuries and extensive shedding of scales result from excessive water motion in the truck cans during transport. When, in 1949, sardines were transported from Monterey Bay to San Francisco, 130 miles in 3.5 hours, it was demonstrated that a single 100-gallon truck can is more satisfactory than four 45-gallon cans.

Mortality in transport was further reduced by providing adequate artificial lighting in the shipping cans so as to reduce mechanical injury of the fish due to contact with the sides of the cans. Overcrowding of buckets and shipping cans is a distinct limiting factor. This study has shown that not more than four adult sardines should be carried in two-gallon buckets, 10 in 45-gallon cans, and not more than 25 in 100-gallon containers.

In the Aquarium:

As stated above, our experience indicates that the number of adult fish in the 1,000-gallon tanks of the Aquarium should not exceed 50. Furthermore, it has been demonstrated that the ill-effects of transportation and

TABLE V

Mortality Due to Causes Other Than Transporting and Handling

Mortality Causes	MORTALITY Number of Fish	 Per Cent
Experimental and Accidental:		
A. Exposure to anesthetic test	5	2.8
B. Overexposure to electrical field	25	14.1
C. Removal for physiological examination after hormone injection	19	10.7
D. Leaping from holding tanks	12	6.7
E. Increase of water temperature in summer months, 1949, 1950	39	21.9
Total	100	56.2
Normal:		
F. Starvation	22	12.3
G. Other factors (overfeeding, pathological causes, etc.)	56	31.5
Total	78	43.8
Grand Total	178	100.0

TABLE VI

Sardine Longevity in Confinement

Shipment Number	*Number of Fish Delivered*	*Number of Fish Survived Critical Period*	*Per Cent of Survival After Critical Period*	*Date of Sardine Delivery*	*Latest Date Recorded for Sardine Survival After Critical 3-Week Period*	*Length of Confinement (in days)*
1	57	0	0	May 19, 1949	——	0
2	37	0	0	Aug. 4, 1949	——	0
3	24	5	20.8	Dec. 22, 1949	June 9, 1950	169
4	128	10	7.8	June 9, 1950	Dec. 3, 1950	178
5	114	16	14.0	Oct. 4, 1950	Dec. 3, 1950	60
5	114	4	3.5	Oct. 4, 1950	Oct. 22, 1951	383
6	116	26	22.4	Dec. 3, 1950	Oct. 22, 1951	324
6	116	10	8.6	Dec. 3, 1950	Jan. 8, 1953	768
7	275	43	15.6	Oct. 22, 1951	Jan. 8, 1953	444
7*	275	8	2.9	Oct. 22, 1951	Feb. 1, 1954	832

*The last survivor of the seventh shipment died on May 16, 1954, after having been kept 937 days in captivity.

handling are felt only during the first three weeks following arrival at the Aquarium. During this critical period, the fish either die or become adapted to the artificial environment, and the survivors may be kept for relatively long periods of time (table VI).

Temperature is a critical factor in maintaining sardines under aquarium conditions. In the Aquarium's tanks without temperature control, water temperatures ranged from 11°C. in winter to 20.5°C. in summer. The greatest mortality, presumably due to temperature, occurred during June and July when the temperature rose to above 20°C.

Our experiments suggest that sardines may be safely kept at aquarium temperatures not exceeding 18°C.

These temperature findings are in accord with available information on the temperature conditions under which sardines exist in the sea. The range of water temperatures at which sardine schools were obtained on scouting surveys conducted by the California Department of Fish and Game was from 11°C. to 20.4°C. (California Cooperative Sardine Research Program, 1951). Daniel Miller* concludes on a basis of field records that "from the general picture it would seem that sardines might prefer temperatures in the range of from 13°C. to 18°C. It must be remembered, however, that these data were collected in all months of the year and within the entire

---

*Scripps Institution of Oceanography, Report on the 1952 Sardine Conference, page 5, October 30, 1952 (mimeographed).

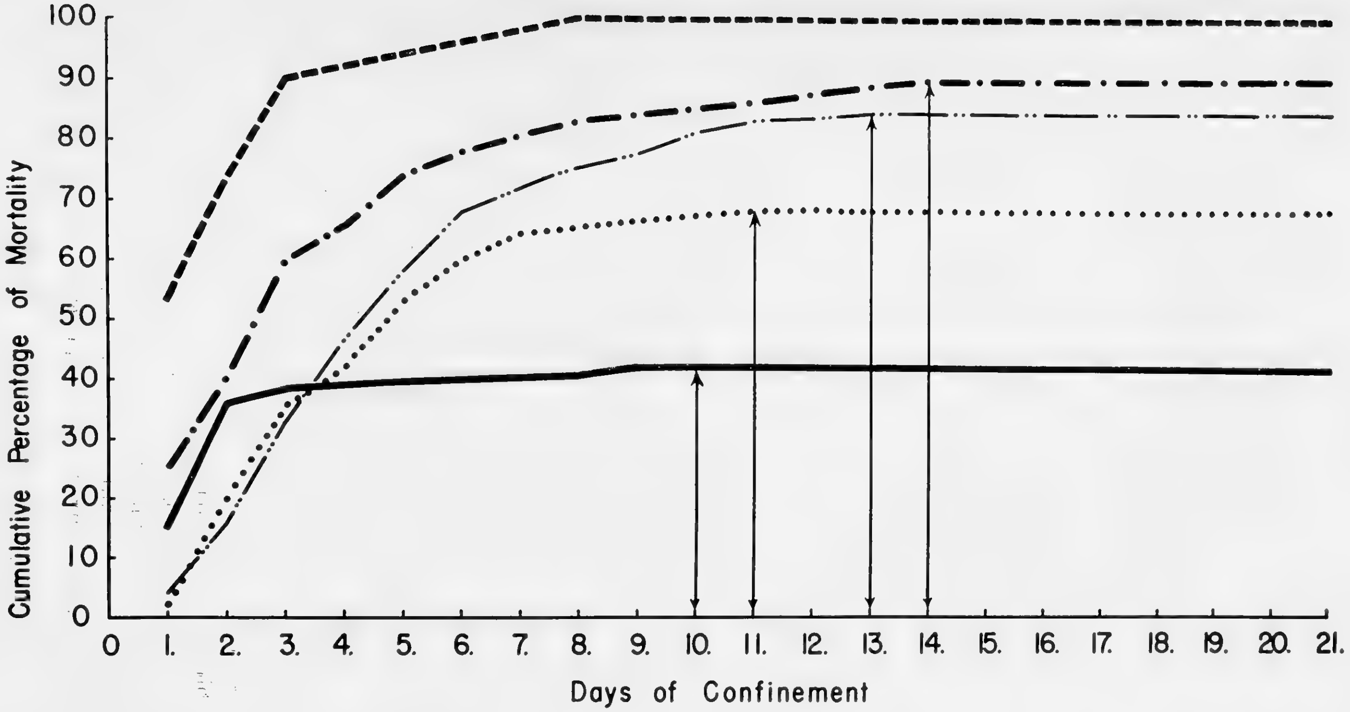


Figure 3. Cumulative percentages of sardine mortality attributable to transporting and handling during the first three weeks of confinement in 1,000-gallon holding tanks at Steinhart Aquarium. - - - first and second Monterey shipments; - . - . - first shipment from the Los Angeles area; - . . - . . - second shipment from the Los Angeles area; . . . . . third shipment from the Los Angeles area; and . - - ______ fourth shipment from the Los Angeles area.

area surveyed off our coast." Schmidt (1936), who studied the iwassi, a Japanese sardine, *Sardinops sagax melanostictus,* states, "Iwassi is very sensitive to temperature and it prefers to keep to regions where the temperature of the surface water is between 12° and 19° C. The sardines begin to advance to our shores in the Peter the Great Bay when water is warmed to a temperature of 8°–10°C., which is usually by the end of May, or in the beginning of June. When water temperatures have reached 12°C., the catches of sardines become abundant. With the increase of water temperature up to 18°–19°C., the sardines move northward in search of cooler water." Suehiro (1951) experimented on the tolerance of the Japanese sardine to sudden temperature changes. He writes, "when sardines which at the time of the experiment were living in sea water of about 22°C. were transferred directly into an experimental tank having a water temperature of 28°C. there was only 10–15% mortality in the course of three hours." When fish from normal temperature water were transferred directly to water with 30°C., "there was within 1 hour and 30 minutes a mortality of 60–100 per cent, a result almost equivalent to total destruction."

During our studies, the *hydrogen ion concentration* of the circulating water in the holding tanks varied from 7.0 to 8.0 *p*H values. Tests on eight adult sardines, 200 mm. in standard length, showed that a *p*H of 6.0 may be tolerated for 24 hours without visible harm.

Artificial light in the transporting cans has been found to reduce mortality. John Radovitch *(in lit.)* states that "A night light is necessary to keep the fish milling instead of smashing into the sides of the tank. A surprisingly large number of fish may be confined in a tank if the tank is large enough to allow the fish to mill in a circle." In the Aquarium, it is not necessary to keep the tanks lighted at night after the critical three-week period. By then, the fish have become sufficiently adjusted to the space factor to avoid injuring themselves against the walls of the tank.

Regarding the *food* of the sardine, Blin (1923), De Buen (1927), and Parr (1930; commenting on a paper by Lewis 1929), stress the importance of copepods. Dr. Cadet Hand* found that 30.8 mg. of organic matter consisting of seven groups—diatoms, dinoflagellates, small copepods, large copepods, euphausiids, chaetognaths, and fish eggs—constitutes an average stomach content for the Pacific sardine. Significantly, the copepods comprised 25.7 mg. or 83.7 per cent of the total weight. Copepods not being readily available, the brine-shrimp, *Artemia salina* was used for food, and it proved to be ideal. For a long period sardines rejected other foods used for different fishes of the Steinhart Aquarium, but after confinement of over a year they readily consumed finely chopped or ground horse heart, fish, and even commercially manufactured dry fish pellets containing protein.

---

*Scripps Institution of Oceanography, Report on the 1952 Sardine Conference, p. 18, October 30, 1952 (mimeographed).

Interestingly, sardines coexist in the Aquarium's tanks with other kinds of fishes, such as grunts, *Brachydeuterus axillaris;* bonefish, *Albula vulpes;* starry flounders, *Platichthys stellatus;* lingcod, *Opiodon elongatus;* staghorn sculpins, *Leptocottus armatus;* and buffalo sculpins, *Enophrys bison.* Usually, the sardines occupy the upper, and the remaining species the lower water layers of the tanks. No intermingling of the two groups has been observed.

In conclusion, this study has shown that, despite its delicate physical structure and high sensitivity to handling, the Pacific sardine may be satisfactorily maintained under aquarium conditions, and that it may, therefore, be subjected to experimental investigations.

Acknowledgments

This work has been carried on with funds provided by the Marine Research Committee as a part of the California Cooperative Oceanic Fisheries Investigations. The authors express their appreciation to Dr. Robert C. Miller, director of the California Academy of Sciences, for his keen interest in the studies and for encouragement and valuable suggestions during the progress of the research; and to Dr. Earl S. Herald, curator of aquatic biology, California Academy of Sciences, for his willing cooperation and valuable counsel; and Dr. Frances N. Clark, director of the California State Fisheries Laboratory, California State Department of Fish and Game; and Mr. John Radovich of the same organization, for helpful suggestions and for their interest in the study. Acknowledgment is made also to Dr. Rolf Bolin, of the Hopkins Marine Biological Station; and Messrs. John C. Marr and Ted Widrig, and Dr. E. H. Ahlstrom, of the U.S. South Pacific Fisheries Investigations, for helpful suggestions and constructive criticism of the manuscript.

LITERATURE CITED

Allen, W. E.

1920. Behavior of loon and sardines. *Ecology,* 1:309–310.
1930. Elusive sardines. *Catalina Islander,* 17(4):10.

Blin

1923. Note sur l'alimentation de la sardine: *Euterpes* et sardines. *Societé Zoologique de France, Bulletin 48*(2–3); 99–105, 4 figs.

Breder, C. M. Jr.

1929. Certain effects in the habits of schooling fishes as based on the observations of *Jenkinsia. American Museum Novitates,* 382:1–5.

Buen, Fernando de

1927. Notes preliminares sobre la biologia de la sardine. *Instituto español de Oceangrafia, Notas y resumenes,* ser. 2, no. 15, 55 pp., 7 figs.

California Cooperative Sardine Research Program
1950. Progress Report, 1950, p. 45.

Cornish, Thomas
1883. Habits of the pilchard. *Zoologist*, London, ser. 3,7:505–506.

Hubbs, Carl L.
1948. "Leapfrogging" by topsmelt and shark. *Copeia*, 4:298.

Janssen, Jr., John F., and J. Alfred Alpin
1945. The Effect of Internal Tags Upon Sardines. *California Fish and Game, Fish Bulletin*, 61:43–62.

Lewis, R. C.
1929. The food habits of the California sardine in relation to seasonal distribution and microplankton. *Bulletin of Scripps Institution of Oceanography, Technical Series*, 2(3):155–180, 2 figs.

Newman, E.
1876. Mr. Saville Kent's lecture, at the Society of Arts, on "The Aquarium: construction and management." *Zoologist*. London, ser. II, 11:4853–4858.

Parr, A. E.
1927. A contribution to the theoretical analysis of the schooling behavior of fishes. *Occasional Papers of the Bingham Oceanographic Foundation*, 1:1–32, 3 figs.

1930. Is the presence of phytoplankton in the stomach contents of California sardine caused by special pursuit or merely due to incidental ingestion? *Ecology*, 11(2):465–468.

Powers, Edwin B.
1921. Experiments and observations on the behavior of marine fishes toward the hydrogen-ion concentration of the sea water in relation to their migratory movements and habitat. *Publications of the Puget Sound Biological Station* 3:1–22, 4 pls.

Schmidt, P. J.
1936. Migration of fishes, First Edition, Moscow-Leningrad, pp. 90–96 (on Japanese sardine), in Russian.

Shelford, V. E., and E. B. Powers
1915. An experimental study of the movements of herring and other fishes. *Biological Bulletin*, 28:315–334, 1 fig., 2 charts.

Shlaifer, A.
1941. Additional social and physiological aspects of respiratory behavior in small tarpon. *Zoologica*, 26:55–60.

Shlaifer, A., and C. M. Breder, Jr.
1940. Social and respiratory behavior of small tarpon. *Zoologica*, 25:493–512, 2 pls., 1 fig.

SPOONER, G. M.

1931. Some observations on schooling in fish. *Journal of Marine Biological Association of the United Kingdom*, new series, 17(2):421–448, 12 figs.

SUEHIRO, YASUO

1951. A study of the causes of death of bait fishes. Translated from the Japanese language by W. G. Van Campen. Washington, D.C., U.S. Fish and Wildlife Service. *Special Scientific Report: Fisheries* no. 62, 57 pp., 1 pl., 15 figs.

PROCEEDINGS

OF THE

CALIFORNIA ACADEMY OF SCIENCES

Fourth Series

Vol. XXVIII, No. 8, pp. 355-392, figs. 1-28 June 30, 1955

NOTES ON AUSTRALIAN AMPHIBIANS

BY

JOSEPH R. SLEVIN

Curator, Department of Herpetology
California Academy of Sciences

The following paper is based upon three separate collections made during the years 1929–1930 (starting on August 1); 1936–1937 (starting on October 3); and 1947–1948 (starting on September 10).

Practically the full six months allowed on a visitor's visa was spent in the field on each trip. This was made possible through the courtesy of the director of the Australian Museum, Dr. Charles Anderson; Dr. A. B. Walkom who succeeded him; and Mr. J. R. Kinghorn, assistant to the director and curator of birds, reptiles, and amphibians, who attended to the various formalities before I arrived in Australia, thus saving much valuable time.

To mention all those whose hospitality and help I enjoyed at the various cattle and sheep stations, on which most of the collecting was done, would be next to impossible. I cannot, however, omit those who "opened the door" to Australia by starting me on my way: Mr. James Burns, of Sydney; Mr. William Kelly, of Brisbane; and Mr. Charles Craig, of Perth, who attended to all my wants in West Australia. To these gentlemen I am deeply indebted for arranging my stops on the various stations whose owners or managers did everything possible to make my efforts a success. Mr. and Mrs. Percy Allan, of the Retro Station, and Mr. and Mrs. Charles Barnard, owners of Coomooboolaroo, cannot be left unmentioned.

Weather conditions were ideal on all three trips. On the third I was fortunate enough to encounter a few light rains which brought out a variety of amphibians not met with before. World War II, however, still had a lingering and disastrous effect on travel conditions and these greatly hindered field activities so that it was impossible to control one's movements or take along all of the necessary collecting equipment. For this reason much valuable time was lost in West Australia at the conclusion of the third expedition.

During the study of the material collected it was found that there were three amphibians which appeared to be new. In order not to run the risk of adding to synonymy these were sent to Mr. Arthur Loveridge to compare with specimens in the almost complete collection of Australian amphibians in the Museum of Comparative Zoology at Harvard. Mr. Loveridge very kindly set aside his own work and spent considerable time studying this material and agreed with me that they were new species. These were originally described in the Proceedings of the Biological Society of Washington, vol. 63, pp. 131–138, December 29, 1950.

LOCALITIES VISITED

Queensland

Callandoon: September 23, 1947–October 3, 1947. A sheep station in the vicinity west of Goondiwindi, southeastern Queensland. This is a thinly wooded area and contains grasslands with scattered ring-barked gum trees of several species and patches of brigalow scrub.

Clermont: August 14, 1929. A town in eastern Queensland at the terminus of the Emerald-to-Clermont railway. It is typical sheep country with open grasslands and scattered gum trees.

Coomooboolaroo: September 15–October 26, 1929, and October 10–November 15, 1936. A cattle station fifteen miles south of Duaringa, east central Queensland. This area is heavily wooded with iron bark trees and much ring-barked country. Several lagoons are on the station but there is no running water, although there are a few stream beds which may have some at long intervals. Many fallen and many dead but standing trees are present. This was one of the best collecting grounds encountered.

Duaringa: November 13, 1936. A village on the Rockhampton-to-Emerald railway fifty-five miles west of Rockhampton.

Gaeta: December 29, 1936, and January 11, 1937. A cattle station ten miles west of Kolonga Creek Station. It consists of heavily wooded and a considerable number of rocky areas. Kolonga Creek runs through this station.

Goondiwindi: September 28, 1947. A town on the Brisbane-to-Dirranbandi railway 140 miles west of Brisbane.

Kolonga Creek: December 24–29, 1936, and January 1–13, 1937. A cattle station twenty-five miles north of GinGin. This area consists of open rolling grasslands with many large gum trees, many of them ring-barked. A moderate-sized and permanent stream (Kolonga Creek), with some deep pools along the banks, runs through the property.

Margenta: November 29, 1936. A sheep station in the vicinity east of Retro and similar in character to it (see below).

McPherson Range: October 3–7, 1936. A wooded mountain range (altitude 2,500 feet) with clearings on the ridges. Some lumbering has been done and there are roads through the virgin forest. On the clear ridges are many fallen trees and burned out logs and stumps of the large gums. This range is located fifty miles inland on the New South Wales-Queensland border.

Noondoo: September 10–20, 1947. A sheep station south of the Noondoo siding ten miles east of Dirranbandi, southeastern Queensland. There are scattered small trees and much open country with artesian-well water. A peculiar formation not seen elsewhere was a number of sand bars paralleling each other across some of the open grasslands.

Retro: August 1–September 10, 1929, and November 30–December 12, 1936. A sheep station twenty miles west of Capella, eastern Queensland. Here are open grasslands and scattered gum trees with moderately heavy groves of the tea tree and an occasional bottle tree. Both black and red soil are in evidence. Though the surrounding country did not look attractive as a collecting ground it proved to be excellent, with a large number of species.

Talafa: November 17–28, 1936. A sheep station twenty miles south of Emerald. It is partly wooded with a heavy growth of brigalow scrub but includes much open grassland. Bottle trees are much in evidence on this station.

New South Wales

Blue Mountains: Localities visited in this region were Cox's River, February 15, 1930; Hampton, February 14, 1930; and the Hampton-Lithgow area, January 19–23, 1948.

Bundy: October 23–November 15, 1947. A sheep station twenty miles southeast of Moree, northeastern New South Wales. This is open grassland with considerable brigalow scrub. A small creek, dried up in the summer months, runs through the property. A small amount of fallen timber and ring-barked trees characterizes this area.

Carroll: November 2, 1947. A sheep station ten miles west of Moree. This consists of the same type of country as that around Bundy Station. It also has a creek which is dried up in the summer months.

Keera: October 14–20, 1947. A cattle and sheep station fifteen miles southeast of Bingara, northeastern New South Wales. This is a wooded, hilly country with the Gwydir River, a fast-flowing stream, running through the property and giving an abundant and permanent supply of water. This region also includes a considerable area of open grasslands with scattered trees.

Sydney: November 7, 1929, February 9, 1930, February 19, 1948. The metropolis of New South Wales.

Ulong: January 27–February 15, 1948. A lumber mill town twenty-eight miles inland from Coff's Harbor, northeastern New South Wales. This is hilly open country with scattered trees and includes several streams of water and an area of virgin forest in which lumbering operations are much in evidence. Numerous log-roads allow access to the untouched areas.

VICTORIA

Ned's Corner: November 20–December 6, 1929. A sheep station on the banks of the Murray River, thirty-seven miles west of Mildura. It is characterized by open grassland and red soil. There is, on the banks of the river, a heavy growth of large gum trees.

WEST AUSTRALIA

Geraldton: January 5, 1948. A town on the coast of West Australia. It is situated between 28 and 29 degrees south latitude.

Nangabrook: January 8–22, 1930. A lumber mill in the heart of the giant gum forests, eighteen miles east of Yarloop on the main southwestern line from Perth to Pemberton. It consists of a virgin forest of giant gum trees with a heavy growth of ferns and grass trees, or "black boys" as they are sometimes called.

PELSART ISLAND

This island, visited December 1–30, 1947, is a coral reef belonging to the southern group of the Abrolhos Islands, forty miles west of Geraldton. Latitude 29° south, longitude 114° east. It is approximately six miles long and three-quarters of a mile wide at the widest part, and is composed of large flakes and small pieces of broken coral, covered in places with low scrub vegetation and a few mangroves in a lagoon in the reef.

SYSTEMATIC LIST OF SPECIES

LEPTODACTYLIDAE

Mixophyes fasciolatus fasciolatus Günther

This name is applied to five specimens, 2 (C.A.S. Nos. 77824–77825) from Cox's River in the Blue Mountains and 3 (C.A.S. Nos. 82049–82051) from Ulong, New South Wales. Loveridge[1] has given the subspecific name *schevilli* to a form from northern Queensland having only two phalanges of the fourth toe free of web, instead of three as in typical *M. f. fasciolatus*. Two specimens from Ulong tend to show this character, but a third (juvenile) has three phalanges of the fourth toe entirely free of web.

In the adpressed limb the tibio-tarsal joint reaches the snout; vomerine teeth in two prominent straight series between the choanae; tongue nitched behind; a large oval tympanum; subarticular tubercles prominent; a large inner metacarpal tubercle and a prominent inner metatarsal tubercle; a prominent crescent-shaped fold of skin over the tympanum.

The color, in life, is grayish or brownish, with irregular patches of a darker shade; limbs of adults with broad crossbars, obsolete in some individuals. The juvenile from Ulong shows distinct narrow bars of black. A characteristic heavy dark-brown bar between the eyes is absent in No. 82050 from Ulong. The thighs are marbled with black and the groin is whitish with black spots. Under surfaces are whitish.

The largest specimen is in the Ulong series, a female (82050) 92 mm. in length. It was dug out of a rotten stump on a grassy hillside.

Cyclorana alboguttatus (Günther)

(Figure 1)

Six specimens (C.A.S. Nos. 77973–77977) from Coomooboolaroo and 1 (C.A.S. No. 77978) from Kolonga Creek.

---

[1] Occasional Papers of the Boston Society of Natural History, 8, p. 55, 1933.

Three individuals show the vomerine teeth in two straight series between the choanae. In one the series touch on the median line and one (No. 77977) has a very prominent single series. Tongue slightly nicked behind; tympanum prominent; two moderate-sized metacarpal tubercles; a large elongate metatarsal tubercle; subarticular tubercles prominent; toes about one-third webbed; in adpressed limb tibio-tarsal joint reaches eye, or slightly beyond.

Skin smooth, with scattered flattened tubercles; a prominent crescent-like fold over tympanum; lateral folds prominent; belly and back of thighs granular; throat smooth.

Color, in life, dark slate to ashy gray; back of thighs covered with small round spots of white; sides mottled with black; belly whitish; a more or less obscure dorsal stripe; throat mottled or clouded with dark gray.

The Kolonga specimen was taken in a puddle under a cattle guard, those from Coomooboolaroo from crevices between the rocks lining a well.

A specimen from Coomooboolaroo measures 60 mm. from snout to vent.

Cyclorana australis (Gray)

Nine specimens (C.A.S. Nos. 77828–77836), the largest species of the genus encountered, were taken at Coomooboolaroo in October and November, 1936, and a tenth one from Kolonga Creek, January 1, 1937.

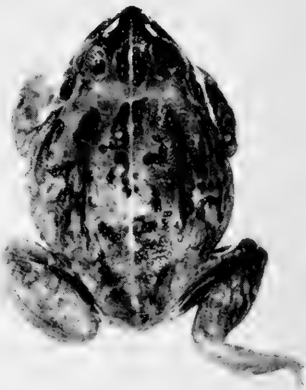


Fig. 1 (left). *Cyclorana alboguttatus* C.A.S. No. 77977, Coomooboolaroo Cattle Station, 15 miles south of Duaringa, Queensland. Natural size.

Fig. 2 (right). *Cyclorana brevipes* C.A.S. No. 77827, Coomooboolaroo Cattle Station, 15 miles south of Duaringa, Queensland. Natural size.

Vomerine teeth in two prominent series between the choanae; tongue slightly nicked behind; tympanum distinct, but moderate in size; two large metacarpal tubercles; a prominent elongate and free-edged metatarsal tubercle; subarticular tubercles prominent; in adpressed limb tibio-tarsal joint reaches midway between tympanum and eye or to the eye; toes slightly webbed.

A very prominent dorsolateral ridge is present. A distinct fold of skin passes from the front of the nostril over the eye and the tympanum to the corner of the mouth. The skin is granular in males and smooth or very slightly granular in females. The toes are slightly webbed.

In life, the dorsal surface is grayish, spotted and marbled with black. The undersurfaces are whitish, the throat being spotted with dark gray in females and uniform dark gray in males. No. 77837, a breeding male, has black inner metacarpal tubercles.

The Coomooboolaroo specimens were taken at 9:30 at night in the high grass alongside a pool of water. The Kolonga specimen was dug out of the lawn in front of the homestead.

This species is known to the pastoralists as the "Bully Frog."

A specimen from Coomooboolaroo measures 87 mm. from snout to vent.

Cyclorana brevipes (Peters)

(Figure 2)

Two specimens (C.A.S. Nos. 77826–77827) are from Coomooboolaroo. Vomerine teeth in two round clusters between choanae; tongue nicked behind; tympanum distinct; two prominent metacarpal tubercles; prominent metatarsal tubercle with free inner edge; subarticular tubercles prominent; fingers rounded; toes slightly webbed; tibio-tarsal joint in adpressed limb reaches to middle of tympanum.

Skin smooth with small, flat warts; sides and belly granular; throat smooth, except that of males which is finely granular; a crescent-like fold of skin over the tympanum.

In life, the color is gray with irregular dorsal spots and blotches. A narrow dorsal stripe is present in the two specimens at hand. Belly whitish; throat of female (No. 77827) clouded with light gray; throat of male (No. 77826) slate color with the edges somewhat darker.

The female measures 48 mm. from snout to vent.

Both specimens were taken on the banks of a lagoon under pieces of bark half buried in the mud.

Cyclorana inermis (Peters)

(Figure 3)

This was a common species at Coomooboolaroo, where 135 specimens

(C.A.S. Nos. 77838–77972) were taken. Five (C.A.S. Nos. 77915–77919) are from Kolonga Creek.

A frog of slender build with a large tympanum situated very close to the eye and about two-thirds as large. Vomerine teeth in two small clusters between fronts of choanae; tongue nicked behind; two small metatarsal tubercles; subarticular tubercles prominent; toes two-thirds webbed; in adpressed limb tibio-tarsal joint reaches snout.

The skin is rugose; belly and back of thighs covered with tubercles; throat smooth; a gular fold present.

In life, the color is gray, with blackish dorsal spots; back of thighs mottled with black; undersurfaces clear, except the throat which is dark in males. The lips are spotted with white.

The entire series were taken in the garden of the homestead, where they were found hidden at the base of the leaves of the pineapple plants. A few were found hopping about the pathways after dark.

Thirty-five mm. from snout to vent is a large individual.

Cyclorana slevini Loveridge
(Figure 4)

Two specimens of this frog (C.A.S. Nos. 82052–82053) taken at Noondoo were described by Loveridge[2]. Its nearest relative appears to be *C.*

Fig. 3 (left). *Cyclorana inermis* C.A.S. No. 77920, Coomooboolaroo Cattle Station, 15 miles south of Duaringa, Queensland. Natural size.

Fig. 4 (right). *Cyclorana slevini* C.A.S. No. 82052, Noondoo, Queensland. Natural size.

---

[2] Proceedings of the Biological Society of Washington, vol. 63, pp. 131-138, Dec. 29, 1950.

australis, from which it differs in interorbital width, size of tympanum, and webbing of toes.

Vomerine teeth in two prominent clusters between choanae; tongue rounded behind; tympanum large, about the size of orbit; an elongate inner metacarpal tubercle; an inner free-edged metatarsal tubercle; subarticular tubercles present, but not prominent; toes two-thirds webbed; in adpressed limb tibio-tarsal joint reaches tympanum; lateral folds absent; belly and anal region granular.

In life, the color is grayish, with darker spots or reticulations. The undersurfaces are yellowish-white.

Both specimens were taken half buried, in sandy soil, under old slabs of bark. The larger one, a female, is 48 mm. in length from snout to vent.

Limnodynastes convexiusculus (Macleay)

A single specimen of this species (C.A.S. No. 78606) was taken at Kolonga Creek.

Vomerine teeth in a long, straight series extending well beyond the outer edge of choanae; tongue oval, tapering toward end and slightly nicked behind; tympanum very indistinct; a prominent inner and slightly smaller outer metacarpal tubercle with an elongate tubercle between; an elongate metatarsal tubercle; subarticular tubercles very prominent and conical in shape; fingers and toes long and rounded, without enlarged terminal disks; a rudimentary web between the third and fourth and the fourth and fifth toe; in the adpressed limb tibio-tarsal joint reaches back of the eye.

The skin is smooth, with the back of the thighs slightly granular.

In life, the ground color is light reddish-brown; a wide blackish band extending from the tip of the snout to the forearm. A whitish tapering stripe from the back of the eye to the forelimb, widest posteriorly; a number of large blackish spots on the sides; three wide blackish dorsal stripes with undulating edges, the center one with a very narrow longitudinal stripe of white; undersurfaces whitish, the throat and sides of belly clouded with reddish-brown.

This, a half-grown specimen, was taken under a piece of bark on the banks of Kolonga Creek.

Limnodynastes dorsalis dumerilii Peters

(Figure 5)

This species was not met with in numbers, only three specimens (C.A.S. Nos. 78035 and 82196–82197) from the Hampton-Lithgow area in the Blue Mountains being taken. All agree in having no dorsal stripe and with the toes devoid of fringes.

Vomerine teeth in a straight series, with a very slight division, and extend to middle of the choanae; tongue rounded behind, tympanum hidden; metacarpal tubercles prominent; a very large spade-like inner metatarsal tubercle; no outer tubercle; subarticular tubercles prominent, those at the base of toes being particularly so; toes slightly fringed and webbed; tibiotarsal joint when carried forward reaches tympanum.

Fig. 5. *Limnodynastes dorsalis dumerilii* **C.A.S. No. 78035, Hampton, New South Wales. Natural size.**

The skin is smooth, covered with minute tubercles and small, flat, glands; an elongate gland extends from the back of the eye to the shoulder; a white lateral fold; a prominent round whitish gland at each side of the vent; tibia with a large, oval-shaped gland; back of thighs covered with small tubercles.

The color, in life, is dark brown with scattered dark markings; sides and belly with dark brown reticulations; throat uniformly dark brown or light brown with reticulations of a darker shade.

The largest specimen of the series measures 69 mm. in length. One (C.A.S. No. 82197) was taken towards late afternoon in a small hollow in the base of a tree.

Limnodynastes dorsalis terraereginae Fry

(Figure 6)

A series of eight specimens; 3 (C.A.S. Nos. 78038–78040) from Coomooboolaroo; 2 (C.A.S. Nos. 78036–78037) from Kolonga, and 3 (C.A.S. Nos. 82198–82200) from Keera have the second finger considerably flattened and heavily fringed.

The vomerine teeth extend to the outer edge of the choanae. The hind leg is slightly shorter than in its congener *L. d. dumerilii,* which it resembles in other respects, except coloration.

Fig. 6. *Limnodynastes dorsalis terrareginae* C.A.S. No. 78038, Coomooboolaroo Cattle Station, 15 miles south of Duaringa, Queensland. Natural size.

A specimen (No. 78036) was colored in life as follows: ground color black; throat, sides and back of jaw yellow; lower lateral surfaces yellow, with black spotting and reticulations; thighs and undersurface of hind legs red; reddish areas on top of forelegs; undersurfaces yellowish, with sides and throat mottled with gray. Two specimens from Keera, two from Coomooboolaroo, and one from Kolonga show signs of a dorsal stripe.

A specimen from Coomooboolaroo is 64 mm. in length. The Kolonga specimens were taken in the water under a cattle guard and those from Keera in newly dug postholes which filled with rain during the night.

Limnodynastes fletcheri Boulenger

(Figure 7)

Twenty-nine specimens (C.A.S. Nos. 82355–82381 and 82389–82390) from Callandoon, 2 (C.A.S. Nos. 82382–82383) from Keera, and 5 (C.A.S. Nos. 82384–82388) from Bundy.

Vomerine teeth in two short series in back of choanae; tongue rounded behind; tympanum indistinct; a large inner and small outer metacarpal tubercle; a small elongate inner metatarsal tubercle; subarticular tubercles present; first finger slightly fringed, second more heavily; toes slightly webbed; in adpressed limb tibio-tarsal joint reaches tympanum.

A prominent fold of skin is present from below the back of the eye to the forearm. The top of the hind legs and the anal region are covered with small tubercles. No. 82371, a breeding male, has a swollen thumb and the bone protruding as in *L. peronii.*

Color, in life, slate-gray, with irregular spots and blotches over the sides and dorsal surface; limbs crossbarred; a black spot under the eye; usually a dorsal stripe of white and a pink spot over the eye; undersurfaces whitish; throat clouded with dark gray.

In the present series of 36 specimens 10 are without the dorsal stripe and 6 lack the pink spot over the eye.

A large male measures 54 mm. from snout to vent.

All were found under old logs or bark in moist depressions in paddocks.

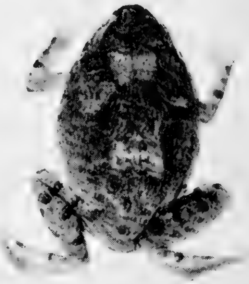


Fig. 7 (left). *Limnodynastes fletcheri* C.A.S. No. 82370, Callandoon Sheep Station, vicinity west of Goondiwindi, Queensland. Natural size.

Fig. 8 (right). *Limnodynastes ornatus* C.A.S. No. 78050, Coomooboolaroo Cattle Station, 15 miles south of Duaringa, Queensland. Natural size.

Limnodynastes ornatus (Gray)

(Figure 8)

Eleven specimens were taken, 10 being from Coomooboolaroo and one from Kolonga.

Vomerine teeth in two straight, or very slightly curved, series extending beyond choanae; tongue slightly nicked behind; tympanum indistinct; a large inner and moderate-sized metacarpal tubercle; large shovel-shaped inner metatarsal tubercle; no outer tubercle present; subarticular tubercles prominent; toes slightly webbed and heavily fringed, in the adpressed limb the tibio-tarsal joint reaches the tympanum.

The skin is smooth with numerous small warts; a cluster of tubercles below the vent; undersurfaces smooth; a cluster of small tubercles at the jaw.

In life, the ground color is purplish-gray with numerous dark spots and reticulations; a dark streak extending through the nostril and eye to the forelimb; a dark band between the eyes and a large squarish spot below the eye; undersurfaces whitish, with the sides of the throat grayish.

The largest specimen measures 39 mm. in length.

All of the Coomooboolaroo frogs were taken at the water's edge of a shallow, muddy lagoon. The Kolonga specimen (No. 78501) has the third finger of each hand greatly flattened and the bone protruding from the tip. Boulenger[3] states in a footnote that a female had on the breast two cicatrices evidently caused by the thumbs of the male. The thumbs in the Kolonga specimen, however, show no signs of a swelling or presence of protruding bone, this, as stated above, takes place in the third fiinger.

Limnodynastes peronii peronii (Dumèril and Bibron)

(Figure 9)

The series at hand comprises 32 specimens from New South Wales, 15 (C.A.S. Nos. 82065–82076 and 77986–77988) from the Hampton-Lithgow area, 5 (C.A.S. Nos. 77981–77985) from Cox's River in the Blue Mountains, and 12 (C.A.S. Nos. 82054–82064 and 82391) from Ulong.

Vomerine teeth in two straight series behind and extending beyond choanae; tongue rounded in back; tympanum hidden; two well-developed metacarpal tubercles; a small to medium metatarsal tubercle; subarticular tubercles present, except on first finger; adult females with two inner fingers flattened and distinctly fringed; adult males with a sharply pointed metacarpal bone protruding from a longitudinal slit on top of the first finger; toes with only a trace of web. This is shown very distinctly in 12

---

[3] Catalogue of Batrachia Salientia, p. 262.

males of the series. In the adpressed limb the tibio-tarsal joint reaches the eye, or between the eye and the nostril, but in none of the specimens does it reach beyond the nostril.

Skin smooth; a distinct fold from the back of the eye to the forelimb; lateral folds present; back of thighs granular; belly and throat smooth.

In life, the color is dark to light gray with a heavy dorsal black line, divided by a narrow white one, from between the eyes to the vent. Prominent lateral black lines are present. The dorsal line is occasionally broken, which happens in two of the Blue Mountain frogs and in one from Ulong. In general, the Blue Mountain frogs are a much darker shade than those from Ulong, which are light gray, and the white line is often obsolete.

Undersurfaces whitish, with throat, sides of belly, and undersurface of hind limbs spotted with gray.

As these frogs have considerable variation as to striping, and having

Fig. 9. *Limnodynastes peronii peronii* C.A.S. No. 77983, Cox's River, New South Wales. Natural size.

prominent, obsolete, or broken stripes, and vary in shade as well, Parker[4] may be safely followed in considering *L. p. lineatus* a synonym.

All of these frogs were taken at night while hunting with a flashlight, the ones from Ulong being found in a small puddle with a heavy growth of grass surrounding it, and those from the Blue Mountains in a hillside spring.

Sixty mm. is the average length of an adult.

Limnodynastes salmini Steindachner

(Figure 10)

This species is represented by 52 specimens, 50 (C.A.S. Nos. 82077–82126) from Callandoon and 2 (C.A.S. Nos. 82127–82128) from Bundy.

Vomerine teeth in two scarcely separated and slightly curved series behind choanae; tongue rounded behind; tympanum indistinct; a large inner metacarpal tubercle and moderate outer one; a large elongate inner metatarsal tubercle; subarticular tubercles moderate. No. 82125, a large female, has a trace of fringe on the second finger; toes with or without a bare sug-

Fig. 10. *Limnodynastes salmini* C.A.S. No. 82115, Callandoon Sheep Station, vicinity west of Goondiwindi, Queensland. Natural size.

---

[4] Novitates Zoologicae, vol. 42, part I, p. 57, April, 1940.

gestion of web; in the adpressed limb the tibio-tarsal joint reaches the tympanum.

Skin smooth; a prominent fold of skin from the back of the eye to the foreleg; a lateral fold present; region of vent slightly tubercular; undersurfaces smooth.

In life, the ground color is gray, with an elongate black patch back of the eye; a small black patch under the eye; a white or pink line from the back of the eye to the foreleg; a broken black dorsal line, with a narrow one of pink down its center; two broad lateral lines of pink, bordered by narrow, broken lines, of black; undersurfaces whitish, sides of the throat clouded with gray.

Sixty mm. from snout to vent is adult size.

The entire series from Callandoon was taken in paddocks drying out from recent rains, but with a few mudholes left. The frogs were under old logs and pieces of bark wherever there was sufficient moisture left. The two from Bundy were under the bark of a fallen tree.

Limnodynastes tasmaniensis Günther

(Figure 11)

A series of 113 specimens are from the following localities: Retro, 20 (C.A.S. Nos. 77790–78009); Magenta, 2 (C.A.S. Nos. 78010–78011); Talafa, 13 (C.A.S. Nos. 78023–78034 and 77987); Coomooboolaroo, 11 (C.A.S. Nos. 78012–78022); Callandoon, 45 (C.A.S. Nos. 82148–82192); Bundy, 2 (C.A.S. Nos. 82194–82195); Keera, 1 (C.A.S. No. 82193); Blue Mountains, 19 (C. A.S. No. 82129–82147).

Vomerine teeth in two straight series behind choanae and somewhat variable in length, extending either to inner edge of the choanae, middle, or in some individuals slightly beyond outer edge; tongue slightly nicked behind; tympanum indistinct; metacarpal tubercles prominent; two metatarsal tubercles; inner slightly elongate; outer very small, occasionally indicated by a white spot; subarticular tubercles present; fingers fringed; toes lightly fringed, with indication of web; in adpressed limb tibio-tarsal joint reaches tympanum or to the back of eye.

Skin smooth, with flattened warts above; a prominent fold of skin from the back of the eye to the forelimb; anal region and back of thighs with prominent tubercles; a dermal flap covering the vent; undersurfaces smooth.

The ground color, in life, is slate or gray, with irregular spots or blotches of black; a black band extends from the nostril through the eye to the forelimb; limbs spotted or crossbarred; occasional areas of pink on the dorsal surface; a dorsal stripe of yellow, pink, or white. The throats of males are suffused with dark gray or slate.

In the present series 36 have the dorsal stripe prominent; in 49 it is obsolete, and in 28 absent.

A female from Retro measures 43 mm. in length.

In the dry sheep country such as Retro and Talafa these frogs were found at night about the watering troughs and tanks or sitting along the pipes leading from the tank to the trough. Farther south at Callandoon they were in the muddy parts of paddocks, where the surface still had some water from recent rains.

Parker[5] is being followed in considering *L. platycephalus* and *L. olivaceus* Loveridge[6] as synonyms.

Lechriodus fletcheri (Boulenger)

(Figure 12)

This was not an uncommon frog in the virgin rain forest in the vicinity north of Ulong where 31 specimens (C.A.S. Nos. 82201–82231) were taken at an elevation of approximately 1,800 feet.

Vomerine teeth in a straight, or very slightly curved, series extending

Fig. 11 (left). *Limnodynastes tasmaniensis* C.A.S. No. 77993, Retro Sheep Station, 20 miles west of Capella, Queensland. Natural size.

Fig. 12 (right). *Lechriodus fletcheri* C.A.S. No. 82201, Ulong, New South Wales. Natural size.

---

[5] Novitates Zoologicae, vol. 42, part I, p. 52, April, 1940.

[6] Bulletin of the Museum of Comparative Zoology, vol. LXXVIII, No. 1, p. 19, January, 1935.

to the outer edge of choanae; tongue slightly nicked behind; tympanum distinct and oval, with minute black tubercles scattered over surface; a large inner metacarpal tubercle and a smaller outer one; a moderately oval metatarsal tubercle; subarticular tubercles prominent; breeding females with first and second toes flattened; toes slightly webbed and heavily fringed; toes of males bordered by minute spines; in adpressed limb tibio-tarsal joint reaches snout.

The skin is smooth, but so heavily covered with minute black tubercles it has the texture of a very fine sandpaper; backs of limbs similarly covered; a prominent fold from the back of the eye to a point midway between the legs; undersurfaces smooth.

In life, this is a remarkably colored frog. There are two shades for the ground color, a light gray or a chestnut brown. A heavy black line extends from the back of the eye, sharp-edged on top and undulating below, encompasses the top of the tympanum and extends to the corner of the mouth. This is occasionally bordered above by a narrow line of pink. Tops of first and second fingers are sometimes black; backs of thighs and undersurfaces of feet are black; the limbs are crossbarred with black, the hind limbs occasionally tinted with pink; the lower surfaces are whitish, the lower jaw being edged with a very narrow black line underneath.

An average specimen of the series at hand measures 44 mm. in length and the largest 50 mm.

All of these frogs were taken in the virgin rain forest where timber was being cut. Ruts formed by the heavy tires of the logging trucks along the roads and filled with water by the night rains were their favorite haunts. On the collecting date, February 15, these frogs were breeding and the puddles contained heavy patches of gelatinous froth containing quantities of small, black eggs.

Adelotus brevis (Günther)

(Figure 13)

This species, one of the most strikingly colored of the Australian amphibians, was taken in three localities, 1 (C.A.S. No. 78052) from the McPherson Range, 2 (C.A.S. Nos. 78053–78054) from Kolonga, and 123 (C.A.S. Nos. 82232–82354) from Ulong.

Vomerine teeth in two oblique series behind choanae; maxillary teeth prominent; tongue rounded behind; tympanum hidden; prominent inner metacarpal and metatarsal tubercles and less prominent outer ones; subarticular tubercles prominent; females with first two fingers flattened and fringed, with slight indication of web; toes with slight indication of web; in adpressed limb tibio-tarsal joint reaches tympanum. At the tip of the lower jaw are two tooth-like erections of skin, very prominent in males and much reduced or hardly discernible in females.

The skin is smooth with a light scattering of small warts, which are heavier and more numerous on the back of the thighs.

In life, the ground color is light or dark gray with irregular markings of black; a large black blotch on the top of the head and a curved band from the tip of the snout, passing through the eye to the corner of the mouth; limbs heavily crossbarred with black; the undersurfaces are rich pink, heavily mottled or reticulated with black. In alcohol this pink disappears rapidly, leaving a dull white color. Some individuals have the throat clouded with gray and minutely spotted with pink.

An adult measures 37 mm. in length.

The McPherson Range specimen was found in the imprint of a horse's hoof in the mud at the side of a water trough, while those from Ulong were found under logs, bark, boards, and various types of debris. A few were found in shallow rain puddles hiding at the roots of the grass and covered with a blanket of small bubbles. No signs of eggs could be found.

Crinia signifera signifera (Girard)

(Figure 14)

This highly variable species was taken in three localities: 36 (C.A.S. Nos. 78066–78101) from Nangabrook; 6 (C.A.S. Nos. 82396–82401) from Callandoon; 1 (C.A.S. No. 82394) from the Blue Mountains; and 1 (C.A.S. No. 82395) from Ulong.

The majority of those from Nangabrook are not mature and it is dif-

Figure 13 (left). *Adelotus brevis* C.A.S. No. 82253, Ulong, New South Wales. Natural size.

Fig. 14 (right). *Crinia signifera signifera* C.A.S. No. 82394, Blue Mountains, New South Wales. Natural size.

ficult to distinguish the characteristics of the species. However, vomerine teeth lacking in more mature individuals; tympanum hidden; a large outer and small inner metacarpal tubercle; palmar and subarticular tubercles very prominent; a small inner and outer metatarsal tubercle; back of thighs granular; belly and sides with flattened granules; dorsal surface smooth. In adpressed limb tibio-tarsal joint reaches close to back of eye.

In life, the color brown or bluish-gray, some individuals with a black lateral stripe from tip of snout to groin; back of thighs occasionally pink; a dark area on dorsal surface back of eyes and a trace of a narrow vertebral stripe; undersurface whitish, spotted, or marbled with black.

The Callandoon specimens are less tubercular and have a tendency towards a uniform grayish, with hind limbs crossbarred with black, while the one from the Blue Mountains has a broad black dorsal band.

One of the largest individuals is 24 mm. from snout to vent.

The entire series was taken under bark slabs or at the roots of grass tufts close to standing water.

Crinia georgiana Tschudi

Eleven specimens (C.A.S. Nos. 78055–78065) were taken at Nangabrook.

Not one of those at hand shows any signs of vomerine teeth; tympanum barely visible; a large outer and small inner metacarpal tubercle; a small inner and outer metatarsal tubercle; palmar and subarticular tubercles prominent; in adpressed limb tibio-tarsal joint reaches to back of tympanum.

The dorsal surface is smooth; belly and sides heavily tuberculated; throat with more flattened tubercles.

The largest specimen in the series measures 32 mm. from snout to vent.

In life, ground color brownish with black areas over dorsal surface; a black lateral stripe from tip of snout to groin, which has a rich reddish to pink area; back of thighs similarly colored; undersurface whitish, sprinkled with black; a dark area in the middle of throat.

This series was taken about the roots of grass tufts close to standing water.

Uperolia marmorata Gray

(Figure 15)

Only two specimens of this species were taken, 1 (C.A.S. No. 82402) at Noondoo, and 1 (C.A.S. No. 82403) from the Blue Mountains.

Vomerine teeth absent; tongue rounded behind, tympanum hidden; a large parotoid gland present; an inner and outer metacarpal tubercle; a prominent elongate metatarsal tubercle and a rounded outer one; subarticular tubercles prominent. The two specimens mentioned show no indication of webbing but have the fingers and toes rounded. In the adpressed limb the tibio-tarsal joint reaches the back of the eye.

Skin smooth with longitudinal rows of small tubercles; undersurface of thighs and the anal region covered with small tubercles.

In life, the color is olive-brown with a white groin patch; back of thighs whitish; undersurfaces yellowish, the throat and belly are clouded with gray and minutely spotted with black.

The larger specimen is from the Blue Mountains and measures 28 mm. from snout to vent.

Both were taken under stones.

Uperolia rugosa (Anderson)

(Figure 16)

This was found to be an abundant species in southern Queensland and was also found in northern New South Wales. It was taken at the following localities: 3 (C.A.S. Nos. 78102–78104) Coomooboolaroo; 182 (C.A.S. Nos. 82404–82584 and 83233) Noondoo; 83 (82585–82667) Callandoon; 5 (C.A.S. Nos. 82668–82672) Keera; 3 (C.A.S. Nos. 82673–82675) Bundy.

Vomerine teeth greatly reduced and barely perceptible in some individuals; tongue oval and free behind; tympanum hidden; an inner and outer metacarpal tubercle; two prominent metatarsal tubercles, the inner compressed and the outer rounded; subarticular tubercles prominent; toes with an indication of fringe; in adpressed limb tibio-tarsal joint reaches to back of eye; a prominent parotoid gland.

The dorsal surface and the back of the thighs are covered with minute tubercles. These are scattered and not in longitudinal rows as in *U. marmorata*. The belly is smooth and the sides of the body finely granular.

Fig. 15 (left). *Uperolia marmorata* C.A.S. No. 82403, Blue Mountains, New South Wales. Natural size.

Fig. 16 (right). *Uperolia rugosa* C.A.S. No. 83233, Noondoo, Queensland. Natural size.

Color in life, silvery gray, groin and back of thigh with large, rich orange blotch; undersurfaces whitish, shaded with dark gray; throat very dark gray to blackish. Preserved specimens present a very different color pattern. It is not until they are in alcohol that the brown to blackish markings covering the dorsal surface appear and the orange changes to white. The average adult measures 25 mm. from snout to vent.

This species was found under any type of cover, but mostly under old bark, stones, or logs. At Noondoo, where it was abundant, it was not uncommon on turning over a log to find as many as six or seven individuals huddled together in remarkably dry, sandy soil.

Pseudophryne bibronii Günther
(Figure 17)

This little toad was not met with in numbers, though it is said not to be uncommon and is widely spread through southeastern Australia. In the Blue Mountains 4 (C.A.S. Nos. 82676–82679) were taken in the Hampton-Lithgow area; 3 (C.A.S. Nos. 78112–78114) on the banks of Cox's River; and 1 (C.A.S. No. 83239) at Bowenfalls. Six (C.A.S. Nos. 78105–78110) are from Coomooboolaroo and 1 (C.A.S. No. 78111) is from Kolonga.

Vomerine teeth and tympanum absent; tongue oval and free behind; a large outer and medium-sized inner metacarpal tubercle; a large inner and medium-sized outer metatarsal tubercle; subarticular tubercles prominent; second and third toes with a slight indication of fringe; tip of fourth toe reaches the snout.

Dorsal surface covered with minute tubercles; back of thighs granular; belly smooth.

Fig. 17 (left). *Pseudophryne bibronii* C.A.S. No. 82678, Blue Mountains, New South Wales. Natural size.

Fig. 18 (right). *Pseudophryne coriacea* C.A.S. No. 82680, Ulong, New South Wales. Natural size.

From my notebook I copy the following description of the specimens taken at Coomooboolaroo. Dorsal surface cinnamon with black reticulations; a canary-yellow patch in back of the forearm; a transverse canary-yellow line above the vent; undersurfaces marbled with black and white. In preserved specimens the yellow turns to white and the cinnamon loses its brightness and becomes a dull brown.

An average individual measures 26 mm. from snout to vent.

Five of the specimens from Coomooboolaroo were taken under a stone in a drying-up creek bed and one under an old piece of wood alongside a water trough.

Pseudophryne coriacea Keferstein

(Figure 18)

A single specimen of this species (C.A.S. No. 82680) was taken under an old log in the rain forest at Ulong.

Vomerine teeth and tympanum absent; tongue oval and free behind; a large outer metacarpal tubercle and a mere indication of an inner one; moderate inner metatarsal tubercle and a minute outer one; subarticular tubercles prominent. With limb adpressed, tip of the longest toe reaches beyond snout.

The dorsal surface is covered with minute tubercles and the sides and back of the thighs are granular.

In life, the dorsal color of this specimen was a dark orange; sides and belly black; undersurface of belly and limbs with irregular white markings.

It measures 25 mm. from snout to vent.

Notaden bennetti Günther

(Figure 19)

Nine specimens of this little toad were taken as follows: 2 (C.A.S. Nos. 82681–82682) from Noondoo; 6 (C.A.S. Nos. 82683–82688) from Callandoon, and 1 (C.A.S. No. 82689) from Bundy.

This is an easily distinguished form, the body being short and stout, almost globular in shape. Mouth very small, legs and toes short, the latter very much flattened and heavily fringed; a large outer metacarpal tubercle and a smaller inner one; a large elongate metatarsal tubercle present; a tubercle at the base of each finger; tympanum hidden.

The skin is somewhat leathery in texture. In life, the ground color is a light pea-green, covered with black warts forming a cross-like pattern on the back, these sometimes being crowned with an orange-colored spot; a number of small, white warts, on the sides and anal region; back of thighs covered with small tubercles. The undersurface is whitish, the throat being covered with black spots.

A specimen from Noondoo (No. 82681) measures 40 mm. from snout to vent.

These toads are reported to be sometimes seen in countless numbers after a rain, but despite the fact that a rain did fall at Callandoon, where the largest series were taken, there were no signs of them while hunting with a light after dark. Those secured were chopped out of a small log half buried in the earth. The Noondoo specimens were found under logs in quite sandy soil.

On account of the cross-like pattern on the back I have heard these toads referred to as the "Holy Cross Toad" and "Catholic Frog."

Hyla adelaidensis Gray
(Figure 20)

This species was met with in only one locality, Nangabrook, West Australia, where 61 specimens (C.A.S. Nos. 78446–78506) were taken.

A slenderly built frog with a decidedly acuminate snout; vomerine teeth in two rounded clusters between choanae; tongue oval, with free edges and nicked behind; tympanum prominent, about two-thirds diameter of the eye; subarticular tubercles prominent; a sharp inner metatarsal tubercle; fingers lightly webbed and toes fully webbed; in adpressed limb tibio-tarsal joint reaches snout.

Fig. 19 (left). *Notaden bennetti* C.A.S. No. 82689, Bundy Sheep Station, 20 miles southeast of Moree, New South Wales. Natural size.

Fig. 20 (right). *Hyla adelaidensis* C.A.S. No. 78454, Nangabrook, West Australia. Natural size.

Skin smooth above, granular on belly and undersurface of thighs; a prominent dermal fold across chest.

This is a brilliantly marked species, if not the most colorful met with. In life, dorsal region greenish gold; a black area from the back of the eye to the shoulder, bordered below by a thin line of yellow, which extends along side to a point midway between limbs; back of thighs black, heavily spotted with yellow; undersurfaces yellow, throat clouded with gray. Forty mm. is average size for an adult.

All of this series were taken in the still waters of a slow-moving stream flowing through the heart of the giant gum forest in the vicinity of Nangabrook.

Hyla aurea (Lesson)

(Figure 21)

Though not an uncommon Australian frog this species was met with only once, at Nangabrook, West Australia, where three specimens (C.A.S. Nos. 78507–78509) were taken.

Fig. 21. *Hyla aurea* C.A.S. No. 78508, Nangabrook, West Australia. Natural size.

Vomerine teeth between choanae in two, slightly oblique, transverse series; tongue oval with free lateral edges and nicked behind; tympanum prominent; two thirds the diameter of eye; subarticular tubercles prominent on fingers, less so on toes; a moderate, wedge-shaped, metatarsal tubercle; fingers with rudimentary webs; toes fully webbed. In adpressed limb tibio–tarsal joint reaches to front of eye.

The skin is smooth. A very prominent fold from the back of the eye over the tympanum to the base of the forearm is present. The sides, belly, throat, and the undersurface of the thighs are strongly tubercular in the more mature specimens.

In life, the three Nangabrook specimens did not show the gaudy colors accredited to this species, the ground color being gray with a tinge of green. A broad dorsal line of light gray and two lateral lines of similar color are present. The area between these lines is dark gray, broken up into large elongate spots on the sides.

The undersurfaces are whitish, with traces of dark gray reticulations. The largest specimen in the series measures 67 mm. and is probably half grown.

Two specimens were found in still water ponds alongside a stream and one was dug out of a hole in the bank of a stream.

Hyla aurea ulongae Loveridge[7]

A single male (C.A.S. No. 83235, Australian Museum Register No. R–13817) was taken at Ulong, New South Wales. Not conforming with the specimens at hand and so as not to add to synonymy it was sent to Mr. Arthur Loveridge, at Harvard College, Cambridge, Mass., who had worked over the extensive Australian collection at that institution and who determined it to be a new subspecies, being characterized by a single series of vomerine teeth between the choanae.

Hyla bicolor (Gray)

(Figure 22)

This little hyla, of which 110 specimens were taken, was found in only two localities, Kolonga Creek and Ulong. From the former locality 37 (C.A.S. Nos. 78254–78290) were taken and 73 (C.A.S. Nos. 82690–82762) are from the latter.

Vomerine teeth absent; tongue more or less oval and nicked behind; tympanum distinct, two-thirds diameter of eye; subarticular tubercles mod-

---

[7] Loveridge, A. New frogs of the genera *Cyclorana* and *Hyla* from southeastern Australia. Proceedings of the Biological Society of Washington, vol. 63, pp. 131-138. 1950.

erate, finger rounded with trace of web at base; toes two-thirds webbed; in the adpressed limb tibio-tarsal joint reaches to tip of snout.

Skin smooth, with a prominent dermal fold across chest; belly and undersurface of the thighs strongly granular, throat slightly so to smooth.

In life, the color is pea-green with a narrow white line extending from a point under the eye to the forelimb; tympanic area blackish; undersurfaces whitish. In two individuals in the present series the white line extends beyond the forelimb to a point midway between the limbs.

An individual 25 mm. in length from Ulong is the largest of the series.

At Ulong these little frogs were taken while sitting on the leaves and stems of wild blackberry bushes in open meadows, and at Kolonga Creek among vines and potted plants about the homestead.

Hyla caerulea (Shaw)

This species is represented by 122 specimens from Queensland and 11 from New South Wales as follows: from Queensland, 19 (C.A.S. Nos. 78116–78134) Coomooboolaroo; 25 (C.A.S. Nos. 78135–78159) Talafa; 3 (C.A.S. Nos. 78160–78162) Magenta; 48 (C.A.S. Nos. 78163–78210) Retro; 17 (C. A.S. Nos. 78211–78227) Kolonga Creek, and 10 (C.A.S. Nos. 83162–83170 and 83226) from Noondoo. From New South Wales, 9 (C.A.S. Nos. 83173–83179 and 83227–83228) Bundy, and 2 (C.A.S. Nos. 83171–73172) from Ulong.

Vomerine teeth in two dome-shaped clusters between and on a level with posterior edge of choanae; tongue round, with free edges, and very slightly nicked behind; tympanum distinct, slightly smaller than diameter of the

Fig. 22 (left). *Hyla bicolor* C.A.S. No. 82740, Ulong, New South Wales. Natural size.

Fig. 23 (right). *Hyla ewingii alpina* C.A.S. No. 83187, Blue Mountains, New South Wales. Natural size.

eye; a moderate-sized outer metatarsal tubercle; subarticular tubercles prominent; fingers and toes heavily fringed; fingers one-third webbed; toes two-thirds webbed; tibio-tarsal joint in adpressed limb reaches eye; disks on fingers and toes very large, width of largest toe disk equaling the diameter of eye, 6 mm. in an individual 83 mm. in length.

The skin is smooth, with the top of the head covered by minute pits. The throat, belly, and undersurfaces of the thighs are strongly granular.

In life, the usual color of adults is a uniform light pea-green, though occasionally a few minute spots of white may occur on the dorsal and lateral regions. The undersurfaces are whitish to light-straw color.

Juveniles may have a few white markings. Two individuals from Bundy, each 36 mm. in length and one from Noondoo, 38 mm. in length, are marked as follows: No. 83227 (Bundy) has a few dorsal and lateral white spots; thighs very sparsely spotted; white patch on forearm; white line from forearm along upper jaw to a point under middle of eye; a white line along back of forearm.

No. 83228 (Bundy) has a minute spot on the forearm, is sparsely spotted on the sides, and has a short white line along the upper jaw extending to a point under the middle of the tympanum.

No. 83226 (Noondoo) has two or three lateral spots; a white line along the back of the forearm; a small spot on the upper forearm; a short line in back of the tympanum on the left side and under the tympanum on the right side.

These frogs were usually found about habitations, where they hide under water tanks, watering troughs, etc., wherever there is a vestige of moisture. The entire series of 17 specimens from Kolonga Creek were taken out of a fireplace in the living room of the station house. Not being in use during the summer the blower was put on tightly and the frogs, bunched up on the brick floor, had an undisturbed hideout. Another favorite spot was under the water tanks about the pastures. The frogs hid out in the daytime under the tanks and around the edges, obtaining sufficient moisture from overflow and leaks which kept the grass damp and green. At night the entire population of a tank would emerge and would sit along the water pipes leading to the troughs, so that just about two visits would be sufficient to capture the entire population of a tank.

The remains of a weevil were found in one of the juvenile specimens from Bundy.

Hyla ewingii alpina Fry
(Figure 23)

Only two specimens of this frog were taken, C.A.S. No. 83186 from Ulong, and C.A.S. No. 83187 from the Hampton-Lithgow area in the Blue

Mountains. This is a larger frog than *H. e. verauxii* and has the dorsal surface covered with minute tubercles.

The color pattern is decidedly different, being grayish with an irregular-edged dorsal band of brown and a large diagonal brown blotch near the groin. The undersurfaces are whitish with grayish throats. Both are males with large vocal pouches.

Both measure 34 mm. from snout to vent.

Hyla ewingii verauxii Dumèril

Eeight examples of this tree frog were taken as follows: 2 (C.A.S. Nos. 78444–78445 from the Cox River, Blue Mountains; 3 (C.A.S. Nos. 83183–83185) Hampton-Lithgow area, Blue Mountains; and 3 (C.A.S. Nos. 83180–83182) are from Ulong.

Vomerine teeth either in two rounded clusters or two elongate series between choanae; tongue oval and nicked behind; tympanum distinct; metacarpal tubercles moderately prominent; a small oval inner metatarsal tubercle; toes three-fourths webbed, except the inner which is without web; fingers with rudimentary webs. In the adpressed limb the tibio-tarsal joint reaches the eye.

The skin is smooth on the dorsal surface and the undersurface of the belly. Throat and thighs are granular.

In life, the color is grayish, with broad lateral stripes of brown. A broad black band extends from the tip of the snout, passes through the eye and over the tympanum, to the forelimb. This is sometimes bordered below with a narrow white line. The flanks are marked with large oval or squarish spots. The undersurfaces are whitish, the throat sometimes clouded with dark gray.

The spotting of the flanks seems to vary somewhat, the frogs from the Blue Mountains being heavily marked, while those from Ulong have few and very small spots.

Hyla kinghorni Loveridge[8]

One example (C.A.S. No. 83234, Australian Museum Register No. R–13818) is from Ulong, New South Wales. Being in the same category as a preceding species *(Hyla aurea ulongae)* it also was sent to Mr. Arthur Loveridge who determined it as new, being closely related to *Hyla palmata*. It was named after the well-known herpetologist, Mr. J. R. Kinghorn, of the Australian Museum.

---

[8] Loveridge, A. New frogs of the genera *Cyclorana* and *Hyla* from southeastern Australia. Proceedings of the Biological Society of Washington, vol. 63, pp. 131-138. 1950.

Hyla latopalmata (Günther)

(Figure 24)

This name is applied to 69 specimens as follows: 45 (C.A.S. Nos. 78539–78577) Kolonga Creek; 7 (C.A.S. Nos. 78532–78538) Talafa; 6 (C.A.S. Nos. 78526–78531) Coomooboolaroo, and 11 (C.A.S. Nos. 83151–83161) are from Callandoon.

These frogs are similar in size and do not appear to differ from *H. lesueurii* in any way except coloration, and this is not absolutely constant. The length of the hind limb varies as it does in *H. lesueurii* and cannot be used as a character. The frogs called *H. latopalmata* have the dorsal surface clouded or marbled with a darker gray than the ground color in 47 out of 69 cases.

Though *H. latopalmata* has been recognized as distinct from *H. lesueurii* the distinguishing characters given do not seem to warrant it. The chief difference given seems to be that the former species is more slender in habit, but in comparing a series of both species that are equal in size this character is not substantiated. As past writers have been somewhat dubious as to its status it may eventually become a synonym of *H. lesueurii,* or at least a subspecies.

Hyla lesueurii Duméril and Bibron

(Figure 25)

One hundred and ten specimens of this hyla were taken; 16 (C.A.S.

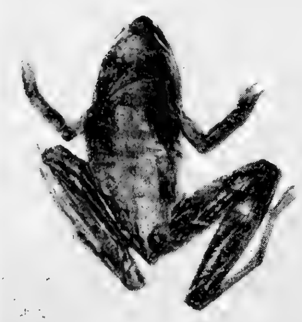


Fig. 24 (left). *Hyla latopalmata* C.A.S. No. 78549, Kolonga Creek Cattle Station, 25 miles north of GinGin, Queensland. Natural size.

Fig. 25 (right). *Hyla lesueurii* C.A.S. No. 78523, Coomooboolaroo Cattle Station, 15 miles south of Duaringa, Queensland. Natural size.

Nos. 78510–78525) from Coomooboolaroo, 29 (C.A.S. Nos. 83058–83080) from Ulong, and 65 (C.A.S. Nos. 83087–83151) from Hampton-Lithgow area.

Vomerine teeth in two elongate series between the choanae, occasionally joining on median line; tongue rounded and nicked behind; tympanum distinct; two-thirds diameter of the eye; subarticular tubercles prominent; a small, oval, inner metatarsal tubercle; outer metatarsal tubercle minute or absent. Out of 23 examples the outer metatarsal tubercle is absent in six; represented by a mere dot in twelve and distinct in five. Fingers without webs, and toes two-thirds webbed. In the adpressed limb the tibio-tarsal joint reaches to a point between the eye and the snout in one, to the snout in twelve, and beyond the snout in ten. In the *vinosa* variety four reach the snout and two slightly beyond.

A fold of skin passes over the tympanum, curving downward to the forearm. The skin is smooth above, the belly and undersurface of the thighs being granular.

The largest specimen in the Ulong series measures 42 mm. from snout to vent and six specimens of the *vinosa* variety 66, 64, 63, 62, 61, 61, respectively.

In life, the ground color was both grayish and buff. Shown under a light at night the buff color was extremely light, but in daylight changed to a much darker shade. A heavy black band starts at the tip of the snout, passes through the eye and over the tympanum to the forearm. There is considerable black marbling in the groin and the back of the thighs. The undersurfaces are whitish, with the throat sparsely clouded with gray. In the *vinosa* variety there are large, white-spotted, black blotches in the groin and the back of the thighs are black with whitish rings, usually with a white spot in the center.

In the daytime these frogs were found under boards and rocks and at night sitting on stones in the bed of a running stream.

Hyla nasuta (Gray)

(Figure 26)

Kolonga Creek was the only locality where this species was found. Fifty-six specimens (C.A.S. Nos. 78578–78605 and 78607–78634) were taken.

Hyla nasuta is a slenderly built frog with nose strongly acuminate and long hind legs.

The vomerine teeth are in two rounded clusters between the choanae. In a single specimen, No. 78579, they show a tendency to be elongated and in an oblique position. Tongue oval, with free edges, and nicked behind; tympanum prominent, about equal to diameter of eye; an elongate inner metatarsal tubercle; a small rounded outer metatarsal tubercle; fingers free of web; toes two-thirds webbed; in adpressed limb tibio-tarsal joint reaches well beyond snout.

Skin smooth, with more or less obsolete longitudinal folds; undersurface of thighs and belly lightly granular; throat smooth; a prominent fold across chest.

In life, the ground color is grayish or brownish with three rows of black, elongate, oval spots down the back; two thin light dorsal stripes separate the middle from the lateral spots; loreal region black; a black line, bordered above and below by a narrower white one on the back of the thighs; undersurfaces whitish. The males have the throats suffused with dark gray.

The entire series were taken in Kolonga Creek, a wide, shallow, and slow-moving stream, running through the station property. The frogs were found floating amongst the patches of grass close to the bank. The average length of an adult in the present series is 46 mm.

Hyla parvidens Peters

This name has been applied, with some hesitancy, to two immature specimens (C.A.S. Nos. 78442–78443) taken on the banks of the Cox River, New South Wales. Neither one shows the adult type of coloration, but some of the characteristics of the species are present; the clear coloring of the back of the thighs, the small tympanum, and the more or less obsolete vomerine teeth. In the adpressed limb the tibio-tarsal joint reaches to the

Fig. 26. *Hyla nasuta* C.A.S. No. 78604, Kolonga Creek Cattle Station, 25 miles north of GinGin, Queensland. Natural size.

eye. The larger one measures 22 mm. from snout to vent and is a slight reddish-brown, with darker marbling or spotting on the dorsal surface. The undersurfaces are whitish. The belly and anal region are tubercular.

Hyla peronii (Tschudi)

(Figure 27)

Fifty-three specimens of this strikingly marked hyla were taken, 18 (C.A.S. Nos. 78228–78245) Coomooboolaroo; 3 (C.A.S. Nos. 78246–78248) Talafa; 5 (C.A.S. Nos. 78249–78253) Kolonga Creek; 18 (C.A.S. Nos. 83206–83220 and 83231–83232) Noondoo; 1 (C.A.S. No. 83221) Callandoon; 3 (C.A.S. Nos. 83237–83238) from Ulong; and 5 (C.A.S. Nos. 83222–83225 and 83229) from Bundy.

Vomerine teeth in two transverse series between the choanae; tongue rounded, with free edges and slightly nicked behind; tympanum distinct, about two-thirds diameter of eye; a small outer metatarsal tubercle; subarticular tubercles prominent; fingers and toes heavily fringed; fingers two-thirds webbed and toes fully webbed; disks on fingers and toes large, the largest equaling diameter of tympanum; in adpressed limb the tibio-tarsal joint reaches to back of eye.

The skin is somewhat rugose. A prominent fold extends from the back of the eye and over the tympanum to the forearm and a pronounced dermal fold across the chest is present. The throat, belly, and the undersurface of the thighs are strongly tubercular.

Fig. 27. *Hyla peronii* C.A.S. No. 78246, Talafa Sheep Station, 20 miles south of Emerald, Queensland. Natural size.

This species is a strikingly marked frog. In life, the color is dark gray to slate, the dorsal surfaces being clouded or marbled with black. The area back of the forearm, the sides, groin, and back of the thighs are marbled or spotted with black and a rich canary-yellow, the latter color completely disappearing in alcoholic specimens. A light gray, and somewhat obsolete dorsal stripe may be present. The undersurfaces are whitish to straw color.

The largest specimen taken is from Ulong and measures 65 mm. from snout to vent. This one, however, is apparently a large specimen, the average length in the series being around 43 mm.

At Coomooboolaroo these frogs were found under the bark of standing trees and at Ulong clinging to reeds in small ponds along the edge of a creek running through an open meadow. The series from the Hampton-Lithgow area were all found under small stones in the dry portions of a river bed.

Hyla rubella Gray

(Figure 28)

This was by far the most abundant hyla met with, 447 being taken as follows: 138 (C.A.S. Nos. 78291–78428) Coomooboolaroo; 5 (C.A.S. Nos. 78429–78433) Talafa; 6 (C.A.S. Nos. 78434–78439) Kolonga Creek; 2 (C.A.S. Nos. 78440–78441) Retro; 153 (C.A.S. Nos. 83230, 82780–82916 and 83042–83057) Noondoo; 7 (C.A.S. Nos. 82917–82923) Callandoon; 136 (C.A.S. Nos. 83188–83205 and 82924–83041) Bundy.

Vomerine teeth in two small clusters between and behind choanae; tongue oval with free edges; tympanum distinct, about two-thirds diameter of eye; subarticular tubercles prominent; a small, elongate inner meta-

Fig. 28. *Hyla rubella* C.A.S. No. 78432, Talafa Sheep Station, 20 miles south of Emerald, Queensland. Natural size.

tarsal tubercle; fingers free of web and toes two-thirds webbed. Loveridge[9] states that specimens preserved in formalin show the fifth toe fully webbed to the base of the disk, but that this condition is not found in alcoholics. The present series is preserved in alcohol and this character is occasionally met with. The disks on the fingers and toes vary considerably in size. In the adpressed limb the tibio-tarsal joint reaches the back of the tympanum.

The skin is smooth above with the sides, throat, belly, and undersurface of thighs, granular. A prominent dermal fold crosses the chest.

In life, the ground color is light or dark cinnamon covered with minute spots of black. A prominent blackish band extends from the tip of snout, through eye, to back of shoulder and occasionally to groin; undersurfaces whitish or yellowish; throat of males suffused with black. Adults average 35 mm. in length.

These hylas sought almost any type of cover and were found in water troughs, holes in fence posts, and under debris and bark of fallen or standing trees. As many as a dozen, or even 20 were found huddled together under a single slab of bark.

Under a light at night the skin is a rich reddish-pink.

A SELECTED BIBLIOGRAPHY USEFUL IN THE IDENTIFICATION OF AUSTRALIAN AMPHIBIANS

Andersson, L. G.

1913. Results of Dr. E. Mjoberg's Swedish Scientific Expeditions to Australia 1910–1913. Amphibia Kungl. Svenska Vetenskapsakademiens Handlingar, Band 52, N:0 4.pp. 1–26, pl. 1.

1916. Results of Dr. E. Mjoberg's Swedish Scientific Expeditions to Australia 1910–1913. Amphibia Kungl. Svenska Vetenskapsakademiens Handlingar. Band 52, No. 9, pp. 1–20, pl. 1.

Boulenger, G. A.

1882. Catalogue of the Batrachia Salientia s. Ecaudata in the Collection of the British Museum. London, pp. 1–502, pls. I–XXX.

1918. On the Papuan, Melanesian, and North Australian species of the genus Rana. *Annals and Magazine of Natural History.* (9) vol. 1, pp. 236–242.

Fletcher, J. J.

1890–1898. Contributions to a more exact knowledge of the geographical distribution of Australian Batrachia. *Proceedings of the Linnean Society of New South Wales*, vol. 5, pp. 667–676; vol. 6, pp. 263–264; vol. 7, pp. 7–19; vol. 8, pp. 524–533; vol. 12, pp. 660–684.

Fry, D. B.

1912. Description of Austrochaperina, a new genus of Engystomatidae from North Australia. *Records of the Australian Museum*, vol. 9, pp. 87–106.

---

[9] Bulletin of the Museum of Comparative Zoology, vol. LXXVIII, No. 1, p. 42, 1935.

FRY, D. B. (Cont.)

1913. On a Varanus and a Frog from Burnett River, Queensland, and a revision of the variations in *Limnodynastes dorsalis* Gray. *Records of the Australian Museum, Sydney*, vol. 10, pp. 17–34.

1913. A re-examination of Macleay's New Guinea and Queensland frog types. *Memoirs of the Queensland Museum*, vol. 2, pp. 46–50.

1914. On a collection of Reptiles and Batrachians from Western Australia. *Records of the Western Australian Museum*, vol. 1, pp. 174–210, pls. XXVII–XXVIII.

1915. Herpetological notes. *Proceedings of the Royal Society of Queensland*, vol. 27, pp. 60–95, pls. 1–4.

GARMAN, S.

1901. Reptiles and Batrachians from Australia. *Bulletin of the Museum of Comparative Zoology*, vol. 39, pp. 1–14.

GLAUERT, L.

1929. Contributions to the Fauna of Rottnest Island. *Journal of the Royal Society of Western Australia*, vol. 15, pp. 43–45.

HARRISON, L.

1927. Notes on some Western Australian Frogs, with descriptions of new species. *Records of the Australian Museum*, vol. 15, pp. 277–287, figs. 1–5.

KINGHORN, J. R.

1924. Reptiles and Batrachians from South and South-West Australia. *Records of the Australian Museum*, vol. 14, No. 3, pp. 163–183.

1932. Herpetological Notes, No. 4. *Records of the Australian Museum*, vol. 18, No. 7, pp. 355–363.

1945. The Simpson Desert Expedition, 1939 Scientific Reports: No. 3, Biology-Reptiles and Batrachians. *Transactions of the Royal Society of South Autralia*, vol. 69, part 1, pp. 3–4.

LOVERIDGE, A.

1933. Four new Crinine Frogs from Australia. *Occasional Papers of the Boston Society of Natural History*, vol. 8, pp. 55–60.

1933. A New Genus and three new species of Crinine Frogs from Australia. *Occasional Papers of the Boston Society of Natural History*, vol. 8, pp. 89–94.

1934. Tasmanian Amphibia in the Museum of Comparative Zoology, Cambridge Massachusetts, *Papers and Proceedings of the Royal Society of Tasmania*, 1933, pp. 56–64.

1935. Australian Amphibia in the Museum of Comparative Zoology, Cambridge, Massachusetts, *Bulletin of the Museum of Comparative Zoology*, vol. 78, No. 1, pp. 3–60, plate.

1936. On some reptiles and amphibians from the central region of Australia. *Transactions of the Royal Society of South Australia*, vol. 62, (2), pp. 183–191.

1950. New Frogs of the Genera *Cyclorana* and *Hyla* from Southeastern Australia. *Proceedings of the Biological Society of Washington*, vol. 63, pp. 131–138

LUCAS, A. H. S.

1892. Notes on the Distribution of Victorian Batrachians. *Proceedings of the Royal Society of Victoria*, vol. 4, pp. 59–64.

1901. Two new species of Frogs from Victoria. *Proceedings of the Royal Society of Victoria*, (2), vol. 13, pp. 175–178.

LUCAS and LE SOUEF

1909. The Animals of Australia. Amphibia, pp. 259–297.

MERTENS, ROBERT

1930. Die Amphibien und Reptilien der Inseln Bali, Lombok, Sumbawa und Flores. Abhandlungen Senckenbergischen Naturforschende Gesellschaft, Frankfort-am-Main, vol. 42, pp. 117–344, pls. 1–8.

NIEDEN, FR.

1923. Das Tierreich. Vol. 46, Amphibia Anura I, pp. 1–584, text figs.

1926. Das Tierreich. Vol. 49, Amphibia Anura II, pp. 1–110, text figs.

NOBLE, G. K.

1931. The Biology of the Amphibia. New York, pp. 1–577, text figs.

OGILBY, J. D.

1907 (1906). A new Tree Frog from Brisbane. *Proceedings of the Royal Society of Queensland*, vol. 20, pp. 31–32.

PARKER, H. W.

1926. New Reptiles and a New Frog from Queensland. *Annals and Magazine of Natural History*, (9), vol. 17, pp. 665–670, figs. 1–3.

1934. A Monograph of the Frogs of the family Microhylidae. British Museum, London, pp. 1–208, 67 text figures.

1940. The Australian Frogs of the Family Leptodactylidae. *Novitates Zoologicae*, vol. 42, Part 1, pp. 1–106, pl. 1, 20 text figures.

PETERS, W. C. H.

1871. Über einige Arten der herpetologischen Sammlung des Berliner Zoologischen Museums. Monatsberichte Akademie Wissenshaft, Berlin, pp. 644–652.

PROCTER, J. B.

1924. Unrecorded characters seen in living snakes and description of a new tree frog. *Proceedings of the Zoological Society of London*, pp. 1125–1129, pls. 1–3.

SPENCER, BALDWIN

1896. Amphibia. Report on the work of the Horn Scientific Expedition to Central Australia, part 2, pp. 152–175, pls. 13–15.

STIRLING, E. C., and A. ZIETZ

1893. On the Reptiles and Batrachians collected by the Elder Exploring Expedition. *Transactions of the Royal Society of South Australia*, vol. 16, pp. 159–176, pls. 6–7.

Van Kampen, P. N.

1923. The Amphibia of the Indo-Australian Archipelago. Leiden, pp. 1–304, 29 text figures.

Waite, E. R.

1929. The Reptiles and Amphibians of South Australia. British Science Guild. Adelaide, pp. 1–270, 192 text figures.

PROCEEDINGS
OF THE
CALIFORNIA ACADEMY OF SCIENCES
Fourth Series
Vol. XXVIII, No. 9, pp. 393–404, 5 tables February 17, 1956

POPULATION GROWTH IN THE WEST AND ITS IMPACT ON NATURAL RESOURCES[1]

By
VARDEN FULLER
Associate Professor of Agricultural Economics and Associate Economist in the Experiment Station and on the Giannini Foundation,
University of California, Berkeley

Let this discussion commence from a perspective of the rate and magnitude of western population growth in the recent past. Tables I–V summarize some of the most relevant data. These data are the basis for several generalizations on western population growth which are essential background for the further considerations implied in the title of this paper. After stating these generalizations, the paper proceeds to some of the interrelations between population growth and economic expansion in the past and concludes with comments on the prospects of the future.

I. Generalizations from the Demographic Data

1. Although the populations of the eleven western states and of the Mountain and Pacific regions have grown rapidly, and at rates considerably in excess of those of the nation, the state-to-state differences within the West are very large, ranging from many times the national average to about half the national average.

2. In the first four years of this decade, a rapid rate of western growth has continued, but in relation to the national rate, it has diminished. Whereas from 1940–1950, the West grew 2.8 times as fast as the nation at large, in the past four years this ratio has dropped to 2.2.

3. Particularly notable is the suggestion in the data that the areas of rapid growth within the region may have shifted in the present decade. Growth rates in the Pacific Region—in Washington and Oregon particularly—have declined sharply. Growth ratios of the Mountain Region have moved upward, though not uniformly and not sharply, except in Arizona and Nevada.

---

[1] Prepared for Symposium on *Natural Resources of the West.* Joint Session of A.A.A.S. Section F and the Western Society of Naturalists, Berkeley, Calif., December 28, 1954.

4. Even though westerners are not noted for infertility, it is true that our outstanding growth rates are attained mainly by large net human import balances. The ratios to be found in table III show the role of net migration. Note the changes of the last four years as compared with the preceding decade. Whereas Washington and Oregon gained 650,000 by net migration in 1940–1950, these states gained only 26,000 in the first three years of this decade. In contrast, the three-year gains in New Mexico and Arizona were not far behind the entire preceding decade, and the three-year gain in Nevada was already ahead of it.

5. Regional and state population growth in the recent past and in the prospective future is compounded out of the forces that influence national fertility and those that impel internal migration. Death rates, though declining gradually, are substantially invariant from year to year and the role of immigration has become minimal, thus leaving fertility as the almost exclusive determinant of national population growth. What is noteworthy is that even after two important erstwhile population variants have been nullified, the future population of the nation still remains uncertain by reason of unstable fertility. And for states and regions, particularly those of the West, future populations are much more highly uncertain because of the complexity of forces that influence migration.

6. Our present high level fertility is now being accepted as an unexpected reversal of a long-time downward trend. As the data in table IV show, earlier marriages and the bearing of children earlier in the marriage are responsible for the marked upturn in total births and in the crude birth rate since 1940. But the evidence does not yet demonstrate an upturn in the size of completed families. Women 20–34 years of age in 1952 had borne significantly more children than had their counterpart generation of 1940. If the fertility level of this generation is sustained through the normal age range of child bearing, this will clearly demonstrate at least a temporary upward revision in the concept of desirable family size, otherwise only that childbearing has been shifted to an earlier age. For evidence that is at all satisfactory on this point, we shall have to be patient until the end of this decade.

7. Within the limits of plausible assumptions as to fertility, the future national population can be projected, and with some degree of intellectual comfort to the projector. As for regional and state populations in the West, similar projections are ventured occasionally, but usually with obvious discomfort, for the forces and occurrences that impel western migration are not readily predictable. The largest movements to California, for example, have been associated with times of unusual prosperity and with the two world wars. Unless one can predict wars and prosperity, he would likely not do well at predicting migration to California, and quite possibly not even then.

TABLE I

Growth of Population in Western States, Other Regions, and United States
1940 to 1950 and 1950 to 1954

(Civilian population in thousands)

Area	1940 to 1950				1950 to 1954		
	April 1, 1950	April 1, 1940	Net Increase		July 1, 1954	Net Increase from April 1, 1950	
	Number	Number	Per Cent	Number	Number	Number	Per Cent
Washington	2,317	1,722	594	34.5	2,459	142	6.1
Oregon	1,519	1,089	430	39.5	1,634	116	7.6
California	10,413	6,858	3,555	51.8	12,213	1,800	17.2
Pacific	14,248	9,669	4,579	47.4	16,306	2,058	14.4
Montana	589	559	30	5.5	624	35	5.9
Idaho	588	559	64	12.1	611	23	3.9
Wyoming	282	246	36	14.5	302	20	7.2
Colorado	1,307	1,120	187	16.7	1,408	101	7.7
New Mexico	668	532	136	25.6	752	85	12.7
Arizona	742	498	244	49.0	974	232	31.3
Utah	687	550	137	25.0	753	65	9.5
Nevada	157	110	47	42.8	209	52	33.1
Mountain	5,021	4,140	881	21.3	5,634	613	12.2
West	19,269	13,808	5,460	39.5	21,940	2,671	13.9
South	46,653	41,543	5,109	12.3	49,214	2,561	5.5
North Central	44,369	40,110	4,258	10.6	46,901	2,533	5.7
Northeast	39,344	35,929	3,415	9.5	41,029	1,686	4.3
United States	149,634	131,391	18,242	13.9	159,084	9,450	6.3

Source: U. S. Bureau of the Census, *Current Population Reports*, Series P-25, Nos. 72 and 104.

TABLE II

Rates of Population Growth in Western States and in Regions as Ratios to National Rates of Population Growth 1940 to 1950 and 1950 to 1954[a]

Area	1940 to 1950	1950 to 1954
Washington	2.48	.97
Oregon	2.84	1.21
California	3.73	2.72
Pacific	3.41	2.29
Montana	.40	.94
Idaho	.87	.62
Wyoming	1.04	1.14
Colorado	1.20	1.22
New Mexico	1.84	2.02
Arizona	3.53	4.97
Utah	1.80	1.51
Nevada	3.08	5.25
Mountain	1.53	1.94
West	2.84	2.21
South	.88	.87
North Central	.76	.90
Northeast	.68	.68
United States	1.00	1.00

[a] Based on data in Table I.

II. POPULATION GROWTH AND ECONOMIC EXPANSION

For rapid population growth based mainly on migration to be sustained, there must be proportionate economic expansion. Otherwise, per-capita incomes will decline and thereby, sooner or later, bring the migration to a halt. If it were true that people lived directly on the yield of natural resources in the area of resettlement, then only sparsely occupied frontier communities could absorb additional population and still avoid the adversity of declining incomes. In so uncomplicated a world, impacts of rapid population growth on natural resources would at some stage become all too obvious. But modern economies, particularly those of the western states, are based upon technologies and institutions that obscure the relations between people and basic natural resources; they have (or at least seem to have) great flexibility and versatility. For the welfare of people, these are indeed fortunate attributes; for the analyst who seeks full and reliable knowledge of man in relation to his physical environment, these attributes contain the seeds of frustration and confusion.

During the three decades for which statistics are available, most of the western states have enjoyed per-capita incomes above the national average.

Large in-migration has had little, if any, adverse effect. In California where the volume of in-migration has been so extraordinary, the income differential has apparently narrowed somewhat but still stands at 20–25 per cent above the national average. For a state that was already well settled and populated to grow by one half in a decade and still maintain most of its premium income position, as was true of California 1940–1950, is something of a feat. For the booster, it is the happy motivation for newer and more lauditory slogans; for the scholar, it poses the challenging obligation to find out how it was accomplished. If we can know something of the economic expansion that is concurrent with rapid population growth, we may therefrom also derive some assistance in knowing its impact on natural resources.

Inasmuch as different states and even areas within states respond differently in the expansionary process, it seems unwise to undertake this inquiry for the western region as a single aggregate. Furthermore, neither the time nor the required analyses are available to permit this inquiry being carried into all states of the West. Accordingly, for this section of my topic, I shall

TABLE III

Net Civilian Migration and Ratios of Net Migration to Natural Increase—1940–1950 and 1950–1953

	Net Civilian Migration (Thousands of persons)		Ratios of Migration to Natural Increase	
Area	April 1, 1940 to April 1, 1950	April 1, 1950 to July 1, 1953	April 1, 1940 to April 1, 1950	April 1, 1950 to July 1, 1953
Washington	354	3	1.40	.03
Oregon	300	23	2.05	.29
California	2,588	977	2.51	1.85
Pacific	3,243	1,004	2.27	1.39
Montana	— 34	— 4	— .47	— .12
Idaho	— 20	— 18	— .22	— .47
Wyoming	— 7	— 2	— .17	.11
Colorado	39	11	.24	.14
New Mexico	12	8	.09	.13
Arizona	138	122	1.20	2.07
Utah	14	— 2	.11	— .34
Nevada	33	36	2.06	4.50
Mountain	174	150	.23	.42
West	3,417	1,154	1.56	1.07
South	—2,017	— 522	— .27	— .18
North Central	50	158	.01	.07
Northeast	615	202	.19	.14
United States	1,976	992	.11	.13

Source: Basic data from U. S. Bureau of the Census, *Current Population Reports*, Series P-25, Nos. 72 and 97.

consider only California. A very recent book by Dr. Margaret S. Gordon, *Employment Expansion and Population Growth, the California Experience 1900–1950,* serves excellently as a basic reference. Additionally, I have drawn upon a chapter by myself on the growth and development of California agriculture which is to appear in a forthcoming book on the California population, sponsored by the Haynes Foundation.

California migration and economic growth are a cobweb of cause and effect relations. Initial movements were provoked by pre-existing economic attractions. For sure, the initiating influence to the forty-niners was a pre-existing attraction. But before very long, people began to realize that it was just as profitable and far more comfortable to mine the miners. And so it has been through the decades. Epochs of migration have been compounded

TABLE IV

Fertility of the National Population

	A. Births and Birth Rates			B. Marriage Rate		
				Per Cent of Females Married		Pct. Increase in Rate
Period	No. of Births (Millions)	Crude Birth Rate	Age Group	1953	1940	1940-1953
1950–1953	10.6	24.8	14–19 years	13.8	9.8	41
1945–1949	17.4	24.1	20–24 years	69.1	51.3	35
1940–1944	14.3	21.1	25–29 years	85.6	74.1	16
1935–1939	12.1	18.8	30–34 years	88.0	80.4	9
1930–1934	12.3	19.7	35–44 years	85.4	81.0	5
1925–1929	13.8	23.2	45–54 years	78.0	76.0	3
1920–1924	14.8	26.8	55–64 years	63.9	63.0	1
1915–1919	14.6	28.4	65–74 years	46.9	41.6	13
1910–1914	14.3	29.8	75 and over	20.0	17.8	12
			Total, 14 and over	66.9	59.5	12

	C. Number Children Ever Born per 1,000 Women			D. Number Children Ever Born per 1,000 Women Ever Married		
Age Group	1952	1940	Per Cent Increase 1940-1952	1952	1940	Per Cent Increase 1940-1952
15–19 years...........	98	68	44.1	572	567	0.9
20–24 years...........	836	513	63.0	1,187	969	22.5
25–29 years...........	1,527	1,090	40.1	1,742	1,408	23.7
30–34 years...........	1,943	1,613	20.5	2,130	1,888	12.8
35–39 years...........	2,112	2,095	0.8	2,293	2,357	— 2.7
40–44 years...........	2,169	2,478	—12.5	2,346	2,740	—14.4
45–49 years...........	2,172	2,735	—20.6	2,352	2,993	—21.4
50 years and over.....	2,707	3,014	—10.2	2,937	3,315	—11.4

Source: U. S. Bureau of the Census, *Current Population Reports*, Series P-25, No. 78; Series P-20, Nos. 46 and 50.

out of the initiating occurrences and out of the self-generationg forces inherent in an expanding population. In general, it may be said that the initiating developments have tended to be more intimately related to natural resources than have the subsequent service industries that were based on the needs of the population. But even this point is clearer in theory than in fact; if it were not ultimately so, then a migrating population could settle anywhere and prosper merely by rendering services unto itself. Yet the resources serving to initiate California's migrations extend considerably outside the usual inventory. Shipbuilding and aircraft manufacture are two of the largest increments of economic activity the state has ever experienced. But the resource base of these industries is not readily identified. For ships, ports on the Pacific were undeniably useful but the potency of the state's politicians was perhaps just as fruitful a resource. For aircraft manufacture, temperature, humidity, the spacing of rains, and the once-blue skies of the California southland were probably the outstanding attributes. Thus, many characteristics of climate and topography, together with whatever spell of magic it was that created Hollywood, must be listed along with gold, oil, forests, and fertile land in California's inventory of resources.

Only in the very first years of the American epoch did agriculture and the extractive industries occupy the major portion of the population. Through the years, employment in these industries has not kept pace with population growth. In consequence, their relative position has consistently receded until they now have less than one tenth of all gainfully employed workers. Meanwhile, such industries as construction, manufacturing, trade, and public administration have expanded at least in proportion with population growth. By 1950, construction occupied about as many workers as did agriculture; distribution and service in total were approximately nine times the size of agriculture.

TABLE V

The National Population to 1975—Possible Maximum and Minimum Projections

	A Series*		D Series†	
Year	**Number** (Millions)	**Percentage Increase Over 1950**	**Number** (Millions)	**Percentage Increase Over 1950**
1955	164.8	8.6	164.4	8.4
1960	177.4	17.0	173.8	14.6
1965	189.9	25.2	180.9	19.3
1970	204.2	34.6	189.1	24.7
1975	221.0	45.7	198.6	31.0

* Assumes age-specific fertility rates of 1950-1953 will continue through to 1975.

† Assumes age-specific fertility rates will decline linearly from 1950-1953 levels to 1940 levels by 1960 and thereafter remain at approximately the 1940 level until 1975.

Source: U. S. Bureau of the Census, *Current Population Reports*, Series P-25, No. 78.

Those whose thinking runs in fundamentalist terms tend to assume that rapid growth to a 12¼-million population must have brought severe impacts upon California's agriculture and its farming resources. However, my interpretation of the evidence leads to a different conclusion. This conclusion derives basically from the fact that in volume and composition of output, California's agriculture has always been primarily responsive to national and international markets rather than to state or western markets. The majority of the state's farming resources have always been used in producing export specialties. With respect to the use of these resources, growth in the size and buying power of the national population has been of major importance, but the proportion of the national population living in California or in the West has not been of much immediate consequence. With the growing of the state population, some of the commodities have shifted from the surplus to the deficit category; this is particularly true of cereals and livestock products. Although profitability in these commodities was enhanced by larger local markets, it still was not sufficient, generally speaking, to induce resources away from the export specialties. Consequently, the state has been and remains one of agricultural surpluses and deficits, with no apparent strong influences toward self-sufficiency.

It is therefore doubtful that the agriculture of California would have been much different from what it is had the state population remained at a fraction of its present magnitude, providing that national and international markets had been as they have. The relevant point of this speculation is that it indicates that the impact of population on agricultural resources, in an economy of well-developed exchange and transport facilities, is more a matter of the national than of state or regional populations.

It is perhaps worth noting the extent to which opportunities in agriculture have been an initiating influence in attracting migrants to California. The historical record of the first two decades of the American regime, 1850–1870, is well marked with expression of lament that the large land holdings were not being divided rapidly into family farms. Immediately following the completion of the transcontinental railroad in 1869, several immigration societies were organized for the principal purpose of stimulating the movement of small farm operators to California. The campaigns that were launched in 1870s and 1880s lacked not in color or versatility of approach. Though they may have had a hand in stimulating general migration, they produced little if any acceleration in the growth of family farming. By 1900, the theme of opportunities for family farmers was largely abandoned and replaced by equally unsuccessful appeals to hired farm hands. The combination of these two failures left a structure of agriculture that was heavily dependent on recurrent infusions of labor from foreign or external sources. Chinese, Japanese, Filipinos, East Indians, Mexicans, and the episodic Okies and Arkies have all had their roles upon this stage. As each infusion lost itself into the total mix of the state's economy, a new one has been sought. In these indirect and somewhat obscured ways, the natural resources of agriculture have perhaps had a greater impact on California's population than has its population upon agricultural resources.

Viewing the state in terms of its aggregate economic growth, or in terms of the development of its principal industries, it is difficult to identify intimate and unobscured relationships to natural resources. Admittedly, within a narrower focus, one can find ghost towns in the mining areas, oil wells that have ceased to flow, forests that no longer hold saw timber, and farm lands for which there is not sufficient irrigation water. Certainly these are impacts—and ostensibly devastating impacts—of population upon natural resources. But whether they are impacts inherently associated with population growth, either state, regional, or national, is another matter. Generally speaking, it seems to me to be more a matter of policy and attitude than of people *per se*. Certainly, the huge mounds of gravel and boulders left in the wake of gold dredgers were not induced by the needs of a growing population but by a most dubious national gold-price policy. This, I admit, is not a particularly instructive example, for gold has very little usefulness, whether diffused in the earth's crust or peacefully resting in the air-conditioned and well-guarded vaults of Fort Knox. But on the other hand, the burden to taxpayers of acquiring and guarding the gold, and the havoc wrought upon streams and meadows in digging it out, are not only clear net losses to society, but also, unfortunately, crushing testimony of man's propensity to concede his resources to political chicanery just as readily as to fundamental needs. Looking at more useful resources, such as timber stands and oil deposits, where the issues are vastly more complex by reason of the conflict between present and future use, one still cannot avoid the conclusion that the manner of use derives less from inherent needs of a growing population than of the policies and attitudes with which we have approached the resource. Certainly, this is true for the renewable resources. As for the nonrenewable deposits of coal, oil, and minerals, there may be nothing morally wrong in removing in a few short years the accumulations of the geologic ages, provided that the contemporary society is fully conscious of the risk taken that, as depletion occurs, fully satisfactory substitutes may not be forthcoming. In any event, there is a considerable range of alternatives which govern the rate of use, quite apart from the size of the population.

III. Appraisal and Prospect

What can be said in appraisal of economic expansion in the West and its relation to natural resources? Truthfully, this is a point that I find highly confounding. As an economic accomplishment, it seems to demonstrate (or to *redemonstrate*) that the greatest natural resource known to man is his own resourcefulness. Evidence of this is found in two directions: first, in the imaginative ability to perceive resource values in obscure forms and combinations; second, in developing so geographically remote an area in close functional relationship with the national economy.

Yet in terms of other values, this expansion may not be seen as a thing of beauty or of high ethical order. The western Indian fared no better than did his counterpart on the Atlantic 150 years before. Native plants and animals have fallen before the rapacious hand of the occupier. Some people believe with Thoreau that "This curious world which we inhabit is more wonderful than it is convenient; more beautiful than it is useful; it is more to be admired than it is to be used." For them the expanding economy of the West must be diabolical indeed. Dry wells, polluted streams, eroded hillsides, and smog may be geologically superficial but nonetheless persuasive evidence that man's engineering abilities were given to him more abundantly than the wisdom to foresee their consequences, or the compassion willingly to abate their nuisances.

Under our system of living, people and their commodities and services are highly mobile. Consequently, in any general consideration of people and resources, no state or region can be a self-contained entity; rather, it is better to think at least in national terms, and even more ideally, in international terms.

Nationally, these are days of growing conscience and concern about resources. The constituting of the President's Materials Policy Commission in 1951 and its comprehensive reports were a major stride in giving effect to this concern. A second major stride was the organizing of the Ford Foundation's Resources for the Future, Inc., which sponsored the Mid-Century Conference on Resources for the Future last December (1953). To William Vogt and Fairfield Osborn these manifestations of concern must have been comforting.

The report of the President's Commission and of the Mid-Century Conference, together with other writings on contemporary problems of population and resources, strongly suggest that a stage has been reached at which broadscale soul-searching is called for. Perhaps this conclusion is no more than the myopic egocentricity that has led individuals of preceding generations to the conviction that their stage of development was somehow peculiarly epochal. Even after acknowledging and discounting this possibility, however, I am still convinced that, to rely on a badly eroded phrase, " a new turn of events is at hand." And it is not impossible, perhaps, that the years immediately ahead will have significance at least equal to the counterpart years of the Industrial Revolution.

Basically, the problem at hand is our unbalanced natural resource budget. Our standard of high living requires prodigious quantities of materials and energy. Furthermore, sustaining the ever-improving material progress to which we are so deeply committed and this, for an expanding population, means rapidly accelerating demands for energy and materials. Except as the finiteness of the resource base is lifted or postponed by research or technology, the prospective relationship between resource demand and supply is more that of collision than of equilibrium.

These recent reports impress one of the exciting possibilities and potentialities for research and technology. It is not at all difficult to be persuaded that there will be substitutes for resources as we now know and use them, and also substitutes for the substitutes. But this has to be largely a matter of faith. And even those of great faith realize we are at the point where, more than ever before, human abilities for research and technological development have to be treated as a scarce resource to be developed and conserved accordingly.

Significantly, both the President's Commission and the Mid-Century Conference identified research and technology as an endogenous force capable of being shaped and manipulated by deliberate policies. The participants in Section VII of the Mid-Century Conference, in discussing resources research, dealt with two matters that are likely to become increasingly familiar to scientists in all fields—namely, organization and communication. These are problems that are exceedingly intricate and delicate. I mention them now, not in the hope of being informative with respect to their solutions, but only to say that, notwithstanding their acknowledged existence, I doubt that either those having an abiding faith in science and technology, or scientists and technologists themselves, fully appreciate the compelling importance of these problems or the imagination and forbearance it will take to solve them.

In closing, let me add another and important dimension to this last point. This is most readily done by quoting a paragraph of wisdom from one of the participants of the Mid-Century Conference—Stanley A. Cain of the University of Michigan:

> Because man is the creator of culture and is at the same time its creature, the problems of resource use are only partially scientific and technological. They are also—perhaps largely—social, economic, and political problems. We cannot definitely realize particular research problems in the absence of the situation in which these problems are created and the answers that are obtained will be applied. Only a deeper and wider understanding of the nature of human ecological problems can bring about the necessary social and financial support for their prosecution and the needed wedding of physical and social fields of research. Here I find the greatest underdeveloped area in the national research program.

Without concurrent and integrated progress in this area of greatest underdevelopment, out of which man may gain a better understanding of himself in terms of his universe, it seems neither irresponsible nor sophistic to "view with alarm."

We presently face two potential juggernauts—population and technology. Conceivably, our technological future could go either to the extreme of being too successful or to that of niggardliness. At the first extreme, there is the danger that man's values may derive too largely from the beguilements of the advertiser; at the second extreme, they may be instilled by the despot thriving upon frustration and despair. At either extreme, or even at an intermediate course of development; confident living will require the deep-seated conservatism and humility with respect to himself that man will have only if he realizes and understands he is the creature as well as the creator of his culture. The conservatism that derives from this knowledge and understanding should be the way to avoid the pitfalls of endeavoring a too-thorough mastery of the universe. There is no compulsion for man, either by reason of his numbers or by reason of grasping for material comforts, to undertake to consume everything the planet has to offer and, in the meanwhile devote his outstanding capabilities to doing it faster and more thoroughly.

PROCEEDINGS
OF THE
CALIFORNIA ACADEMY OF SCIENCES
Fourth Series

Vol. XXVIII, No. 10, pp. 405–414 February 17, 1956

WATER RESOURCES OF THE WEST, TODAY AND TOMORROW[1]

By

MARTIN R. HUBERTY

Chairman and Professor, Department of Irrigation and Soils,
University of California, Los Angeles

The West, as herein defined, is represented by the 17 western states and includes all or parts of the following major drainage basins: North Pacific Coast (I), South Pacific Coast (II), Great Basin (III), Gulf of California (IV), Gulf of Mexico, exclusive of Mississippi River (V), and parts of the Western Mississippi River (VI), and the Hudson Bay drainage basins (VII).

The area is large (some 1,817,000 square miles) and possesses many sharp contrasts: contrasts in the amount, distribution, and character of precipitation; in the nature of its streams, from large rivers of sustained flows to arroyos that are only occasionally wet by flash flows; in elevation from peaks in excess of 14,000 feet to depressions below sea level; and in population, from densely populated industrial cities of the Pacific and Gulf coasts, to unpopulated mountainous regions. Only about 2 per cent of the area is irrigated.

Increase in Water Demand

Phenomenal increases in population and in industrialization have placed a heavy and continuing demand upon the water resources. These uses include water for irrigation, industry, home, navigation, and recreation. Certain uses do not deplete the water supply or affect its quality, such as the generation of electricity, but water used for irrigation is largely lost to the atmosphere by evaporation; while industrial and domestic uses often tend to degrade water quality without materially reducing the supply.

North Pacific Coast Basin (I). This includes the drainage basin of the Columbia River plus a few small coastal streams, mainly in southern Oregon. A description of the Columbia River will characterize the water

---

[1] Prepared for Symposium on *Natural Resources of the West.* Joint Session of A.A.A.S. Section F and the Western Society of Naturalists, Berkeley, Calif., December 28, 1954.

situation of Basin I. This river, the second largest in the United States, has a mean annual flow of about 180,000,000 acre feet. Approximately 40 per cent of the flow originates outside of the United States in Canada. Of the remaining 60 per cent, 25 per cent originates in the relatively small area of the Cascades, 25 per cent in the plateau area, and 50 per cent in the Rockies. The Cascade section has heavy winter precipitation and runoff, while the snow pack of the Rockies provides the principal natural flow of late summer.

The Columbia River is a relatively low gradient stream, yet because of its large flow, has tremendous power potentialities: one-sixth of the nation's hydroelectric power is generated by plants on this stream; yet to date only about 10 per cent of the total 30 million kilowatts of potential power is developed.

Presently irrigated lands of the basin do not place a heavy demand on the water supply, only about 5 per cent of the total water supply being used for irrigation. It is estimated that approximately 4 million acres more can be brought under irrigation.

Some of the industries of the area require large volumes of water for their operation. The large water supply available at relatively low cost has not required the employment of water-conserving practices.

Since the Columbia is a very important fish stream, provisions for the movement of migratory fish have to be a part of any water-development program of the area.

SOUTH PACIFIC COAST BASIN (II). With the exception of a small part of the upper portion of the Klamath River watershed, this is located within the state of California. Seven hydrographic subbasins within the state are recognized; all but No. 6 and part of No. 7 being within the large South Pacific Basin.

The first of these areas or subbasins is a section of high winter precipitation and runoff. Forty per cent of the state's estimated annual water supply of about 70,000,000 acre feet is to be found in this area, which represents about one eighth of the state's area. Because of the rugged topography and sparse population, there is little demand for the water locally. Plans for the transporation of some of the water to areas of deficient supply are being formulated.

Subbasin 2, San Francisco Bay area, some 4,400 square miles in extent, is densely populated and highly industrialized. Average annual precipitation is slightly less than 25 inches, mainly in the form of winter rain. Since the average runoff of about 1¼ million acre feet does not equal demand, the two large metropolitan areas, San Francisco and the East Bay, have each gone to the Sierra Nevada for additional water.

Subbasin 3 is slightly in excess of 11,000 square miles, with an annual runoff of about two and a half million acre feet. This is another area of over-all water deficiency. Except for the northern part, it would be very expensive to provide a supplemental water supply.

Subbasin 4 is a densely populated, highly industrialized area where over half of California's twelve million people reside. From this 11,000 square miles, about 6 per cent of the state's area, the average annual runoff is about 1¼ milion acre feet, or 1.8 per cent of the state's total.

The first major importation of water to southern California was made in 1913, when water was transported from Owens Valley, on the eastern side of the Sierra Nevada. Recently the project has been extended northward to include the Mono Basin.

During the '20s thirteen southern California cities joined to obtain Colorado River water. The main aqueduct, with a capacity of 1600 cfs, was completed during the '30s and now most of the important cities in southern California, including San Diego, are members of the water district.

Ground waters are utilized to a high degree. In fact, in certain areas adjacent to the coast the ground water levels have been lowered to such an extent that salt water intrusion is occurring. To combat this menace tests have been made on the effectiveness of an interposed fresh water dike between the ocean and the ground water basin to exclude the sea water. Water has also been obtained from the aqueduct of the Metropolitan Water District of Southern California to recharge the underground aquifers.

Subbasin 5 is the site of the well-known Central Valley Project. Actually, the valley is divided into a number of subsections, the main ones being the Sacramento and the San Joaquin valleys. Three eighths of the state's area, responsible for about a third of the total runoff, is included in this division. The northern part, the Sacramento Valley, appears to have excess water, while in the south the reverse is true. In the main, then, the problem is one of moving the water southward.

The key unit in the project is Shasta Dam. It serves irrigation, power generation, flood control, navigation, salt water repulsion in the lower basins, and recreation. As water for irrigation represents about 90 per cent of California's water use, most emphasis has been placed on the irrigation aspects of the project.

The plans provide for the use of the extensive underground basins as regulating reservoirs. The estimated ground water capacity of the Sacramento-San Joaquin valley, between limits of 20 to 200 feet, is 130 million acre feet, or more than four times the effective storage capacity of Lake Mead, back of Hoover Dam. Joint use of surface and ground water storage provides a very flexible system to compensate for the irregularities in yearly and seasonal runoff.

Completion of the Friant-Kern Canal came none too soon, as some of the ground water basins were being depleted.

Subbasin 6 lies to the east of the Sierra Nevada, and although much of it is relatively high, the average rainfall is comparatively low. Runoff averages over 3 million acre feet yearly, of which much flows into Nevada through the Truckee, Walker, and Carson rivers. The City of Los Angeles diverts water from part of this region. The hydroelectric power potentialities of the area are fairly well developed by the city and public utility companies. This subbasin is a part of the Great Basin and will be mentioned again.

Subbasin 7, in the southeastern part of the state, is a region of extreme aridity, averaging about four inches of rain per annum, and with an average runoff of less than 200,000 acre feet, exclusive of the contributions of the Colorado River. Palo Verde, Imperial, and Coachella valleys receive water from the Colorado River, the latter two from the All-American Canal. The water problems of the area are mainly those of deficiency, except in those sections which receive water from the Colorado.

Great Basin (III).—This is a sparsely settled region of high basin plains and mountains, with no drainage to the ocean. The climate is arid to semiarid except at the higher elevations. The major use for water in the area is irrigation.

No major streams are to be found in this area. Flows from the eastern slopes of the Sierra Nevada in California contribute about 3 million acre feet per annum, while the Humboldt River is the principal stream in the state of Nevada.

Within the Great Salt Lake subbasin are the Bear River and the Weber River systems. Both streams are fairly well regulated by storage reservoirs. Despite this fact, some one million acre feet of water enter Great Salt Lake yearly. While some of this can be conserved, it should be pointed out that in irrigation it is necessary to waste a certain percentage of water applied so that soluble salts will be removed from the soil. The Weber basin receives some water through a diversion from the Colorado Basin, as does the Sevier subbasin in the southwestern part of the state.

The Bureau of Reclamation's plan for the upper Colorado provides for importation of water from the Colorado River Basin into Utah.

Gulf of California (IV). This includes the Colorado River watershed and a few minor streams. Except for the northern portions of the basin, the area is characterized as arid. Although the Colorado River watershed is nearly as large as that of the Columbia River, its flow is only about one tenth of that of the latter. Within this basin, representing about one twelfth of the area of the United States, less than one per cent of the nation's population resides.

The principal tributary of the Colorado is the Green River. The Colorado and the Green are fed mainly from snow, so have good summer flow. It is estimated that three fourths of the river's flow originates in the basin above the mouth of the Green River in southern Utah. While estimates vary as to the average annual flow of the river at the Mexican border, it would be about 17 million acre feet under natural conditions. Typical of stream flow in arid regions, fluctuations are wide, ranging from 5 million to 25 million acre feet, and the flow above Lake Mead from 700 to 300,000 cfs. Since Hoover Dam has been constructed, the downstream flow has varied from slightly under 2,000 to about 26,000 cfs.

The great overriding problem of the Colorado Basin is the attempt to meet the many demands for water. These demands greatly exceed the supply. This has caused many controversies. In 1922 the Colorado River Compact was signed by the representatives of six of the interested states. Under this compact 7,500,000 acre feet per annum was apportioned in perpetuity to both the upper and lower basins, Lee's Ferry marking the boundary between them. In addition, the lower basin was appropriated a million acre feet. Water unappropriated after October 1, 1963, might be divided among the states.

Under terms of an international water treaty with Mexico 1,500,000 acre feet annually are assigned to that country. This is to come from the amount allotted to the lower-basin states.

Because of aridity, farming in the basin is not practical without irrigation. Some two and three-quarter million acres of land are now irrigated within the basin proper, plus slightly less than half a million acres in the Imperial Valley. Exclusive of the Imperial Valley, the area irrigated is about equally divided between the upper and the lower basins. However, because of aridity, water requirements per unit area are greater in the lower basin.

Within the past score of years a series of dams have been built, including Hoover, Davis, Parker, Imperial, and most recently Morelos Dam, a structure built by Mexico just south of the border. In addition to the dams are the great irrigation systems, including the All-American Canal serving the Imperial and Coachella valleys, and the extensive system now being built into the Gila Valley.

Plans by the Bureau of Reclamation for the river's development provide for ten large dams in the upper basin capable of storing some 48.5 million acre feet of water for multipurpose use. Besides providing for irrigation of new land in the upper basin, estimated at 380,000 acres, the development will provide a supplemental supply to nearly a half-million acres now developed, much of which lies outside the drainage basin of the Colorado in Utah and Colorado. Transmountain diversions of Colorado River water to areas east of the Rockies amount to about 200,000 acre feet annually, and another diversion of 300,000 acre feet is contemplated. Diversion of low-salt content water from the upper basin will have a deleterious effect on the water quality of the lower basin, the quality of which will continue to deteriorate as the upper basin states increase their water use.

The heavy sediment load of the Colorado poses the very serious problem of reservoir silting and stream channel clogging. High river gradient and poor vegetative cover over much of the catchment are important contributing factors. Five million acre feet is provided in Lake Mead for debris storage. Additional control works are required upstream so that excessive flows, the main contributor to debris movement, will be reduced. Not all silt problems are confined to the stream above Hoover Dam. The desilted water from each of the storage reservoirs has caused a degrading of the stream channel immediately below the structure and an upgrading immediately above the next downstream structure.

Present hydroelectric plants on the Colorado River have an installed capacity of over 1½ million kilowatts. The Hoover Dam plant has the largest output, while power from Parker will be used mainly to deliver water to the system of the Metropolitan Water District of Southern California against a total head of over 1,600 feet. Estimated total potential hydropower for the basin is about 6,500,000 kilowatts.

Arizona is the only state in this basin that makes extensive use of ground water. During the period 1948–1953 some 400,000 acres were brought under irrigation, mainly through the use of ground water.

Gulf of Mexico Basin (V). This is an area where the demand for water for irrigation and industry is expanding very rapidly. Ground water supplies have been developed to a high degree, in some instances overdeveloped. Additional supplies can be provided by storage of the flood waters on those streams draining the central part of Texas. In fact, some of the streams in the Mississippi Basin are potential sources of additional water for this basin.

The Rio Grande River, an international stream, is the principal river of the basin. Rising in Colorado, it flows some 1800 miles to the Gulf of Mexico. It has a watershed of 185,000 square miles, of which 57 per cent is in the United States. Practically the entire flow of the upper portion of the stream, some 3 million acre feet, is used locally, mainly for irrigation. The downstream flow's annual average, about 5 million acre feet, is provided by tributaries arising in Mexico and from the Pecos River. Elephant Butte and Falcon are important water-impounding structures which help control stream flow. An important feature of stream regulation is the maintenance of a desirable salt balance. In order not to build up an undesirable amount of salt in the irrigated lands, a certain amount of water must be released so that excess salt will be carried out of the basin to the Gulf of Mexico.

Among the streams to the east of the Rio Grande are the Nueces, San Antonio, Guadalupe, Colorado, Brazos, Sabine, and Trinity. Most are subject to wide seasonal and annual variations in flow, conditions which generally make storage expensive. The hydroelectric output of the area is not large, but the basin generally does not lack for power because of the great oil and gas resources.

Mississippi River (VI). This area drains all of five states and parts of six others, more than a half-million square miles, and extends from the Canadian border to the Gulf of Mexico. It includes the Missouri River basin plus such other important streams as the Red, White, Black, and Arkansas rivers. While most of the important tributaries have their sources in the Rockies, the major portion of the basin occupies plain lands to the east.

For a long time the chief attention given to these streams concerned flood control. Now a huge multipurpose project is underway to develop the water resources of the area for a wide range of uses. Within the past decade there has been a marked increase in irrigation. Grasslands are giving way to irrigated farms.

Important tributaries of the Missouri River from the west include Milk, Yellowstone, Cheyenne, Platte, and Republican rivers. The Yellowstone is an important tributary with an average annual runoff of nearly 7 million acre feet. Its flow characteristics are similar to the other tributaries that drain the Rockies. The major portion of the runoff occurs during April, May, and June.

A comprehensive federal program for the Missouri Valley is now under construction. It contemplates the ultimate construction of some 90 reservoirs, which will have a capacity of about 46 million acre feet. Reservoirs on the tributaries will be used for irrigation, flood control, and power development. Main river storage will be chiefly for navigation improvement, power, and irrigation. It is estimated that the ultimate development will bring under irrigation about 5 million acres, and produce nearly four billion kilowatt hours of electricity annually.

Surely this area is undergoing a transition period.

Increasing the Effectiveness of Our Water Resources

Cloud seeding and sea water reclamation are two proposals that often appear in the news. To what extent precipitation can be increased by cloud seeding is still a question upon which there are many opinions. Extensive experiments on demineralization of sea and less saline waters are now being conducted. Results to date show promise for the reclamation of waters which are slightly too saline for irrigation use, but the problem of reclaiming sea water at a cost which is currently considered reasonable is yet to be accomplished.

The avenue that offers the greatest opportunity to increase the effectiveness of our water resources is to increase the use-efficiency. Farmers can adopt better means of water application, industry can, through re-use, materially reduce the requirements for large flows; and through the elimination of large areas of noneconomic, high-water-consumption plants, water can be conserved. A conscious effort should be made not to pollute the water supply unnecessarily, so that it will be available for re-use. Surface and ground water storage of flood and other surplus water, although often expensive, has to be resorted to in the semiarid and arid sections.

Water Resources of the Future

I have no crystal ball, nor am I the seventh son of a seventh son, but certain trends in the development and use of our water resources do seem fairly clear. For the Northwest Basin, the development of the tremendous power potential of the Columbia River will continue, giving rise to a great industrial development. Irrigated acreage will increase, but despite all local demands, some 150,000,000 acre feet of fresh water will pass annually into the sea.

In the South Pacific Basin great efforts will be made to equalize the geographic disparity between water resources and water demand. Maintenance of acceptable water quality, especially in the ground water basins, will be a problem. Careful use of water by farmers and industry will increase water use efficiency, including re-use of some of the water now wasted to the sea by coastal cities. Some of the isolated ground water basins will be pumped to the economic limit and then abandoned so far as irrigation is concerned.

As for the Great Basin, it is difficult to visualize great water resource potentialities despite the proposed diversions from the Colorado River. The basin is rich in mineral wealth but not in water.

The Gulf of California Basin will always be an area of low water supply. Upper Colorado River development will harness the water for multipurpose projects. This will result in a general degrading in water quality downstream.

In the Gulf of Mexico Basin west of the Mississippi, especially in the eastern and south central portions, the indications are that there will be a strong demand for the harnessing of local water supplies, together with a move to bring water from the northeast. The great industrial potential of the coastal section is in no small measure associated with good water supplies.

The western Mississippi River basin will undoubtedly undergo marked changes during the next few decades. Available water during late summer and low-cost power will favor expansion of irrigation and encourage industrial development. Harnessed water resources will permit higher use of much of what the American people have come to know as the grasslands.

SELECTED LIST OF LITERATURE ON THE WATER RESOURCES OF WESTERN UNITED STATES AND THEIR DEVELOPMENT

CALIFORNIA, STATE OF

1951. Water Resources of California. *Water Resources Bulletin* 1, pp. 1–648.

HYATT, EDWARD

1930. Report to the Legislature of 1931 on State Water Plan. *California Division of Water Resources Bulletin* 25, pp. 1–204.

MILLER, MEREDITH R., GEORGE HARDMAN, and HOWARD G. MASON

1953. Irrigation Waters of Nevada. University of Nevada. *Agricultural Experiment Station Bulletin* 187, pp. 1–63.

MITCHELSON, A. T., and DEAN C. MUCKEL

1937. Spreading Water for Storage Underground. *United States Department of Agriculture. Technical Bulletin* 578.

PRESIDENT'S WATER RESOURCES POLICY COMMISSION

1950. Vol. 1—A Water Policy for the American People. Pp. 1–445.
Vol. 2—Ten Rivers in America's Future. Pp. 1–801.
Vol. 3—Water Resources Law. Pp. 1–777.
United States Government Printing Office. Washington, D. C.

SMITH, G. E. P.

1922. The Colorado River and Arizona's Interest in Its Development. University of Arizona. *College of Agriculture Bulletin* 95, pp. 529–546.

THOMAS, W. P., *et al.*

1949. Colorado River and Utah's Agriculture. *Special Report* 1, *Utah State Agricultural College*, pp. 1–33.

THORNE, J. P., and D. W. THORNE

1951. Irrigation Waters of Utah. *Utah Agricultural Experiment Station Bulletin* 346, pp. 1–64.

TODD, DAVID K.

1953. Sea-Water Intrusion in Coastal Aquifers. *Transactions of the American Geophysical Union*, vol. 34, no. 5, pp. 749–754.

UNITED STATES CONGRESS

1952. II. The Physical Basis of Water Supply and Its Principal Uses. Interior Insular Affairs Committee. Pp. 1–93.

1953. III. Ground Water Regions of the United States—Their Storage Facilities. Interior Insular Affairs Committee. Pp. 1–78.

UNITED STATES DEPARTMENT OF AGRICULTURE

1948. Irrigation Agriculture in the West. *Miscellaneous Publication* 670, pp. 1–39.

UNITED STATES DEPARTMENT OF COMMERCE

1950. Irrigation of Agricultural Lands. United States Census of Agriculture. United States Government Printing Office. Washington, D. C.

United States Department of Interior

1946. The Colorado River, a Natural Menace Becomes a National Resource. Bureau of Reclamation. Pp. 1–295.

1947. The Columbia River. Bureau of Reclamation. Volume 1, pp. 1–399.

1948. Report on Central Arizona Project. Bureau of Reclamation. Mimeographed.

1950. The Columbia River. Bureau of Reclamation. Pp. 1–690.

United States Geological Survey

Water-Supply Papers, Surface and Ground Water. Numerous—United States Printing Office. Washington, D. C.

United States Senate

1944. Missouri River Basin, Conservation, Control and Use of Water Resources. Senate Document 191. 78th Congress, 2nd Session. Pp. 1–211.

University of Oregon

1953. Research in the Policy and Administration of Natural Resources. Department of Political Science. Eugene, Oregon. Pp. 1–68.

PROCEEDINGS
OF THE
CALIFORNIA ACADEMY OF SCIENCES
Fourth Series

Vol. XXVIII, No. 11, pp. 415–423 February 17, 1956

FORESTS FOR THE FUTURE[1]

By
STEPHEN N. WYCKOFF
Executive Vice President, Forest Genetics Research Foundation

This discussion pertains to the future productivity and management of the commercial forest lands of the ten western states, the area extending from the eastern borders of Montana, Wyoming, Colorado, and New Mexico to the Pacific Ocean. Commercial forest land is defined as "forest land bearing or capable of bearing timber of commercial character and economically available now or prospectively for commercial use and not otherwise withdrawn from such use" (1). Noncommercial forest land is chiefly valuable for purposes other than timber production. Since its management differs markedly from that of commercial forest land, it lies outside the scope of this paper.

The western states contain some 108 million acres of commercial forest land, mostly in Montana, Idaho, Washington, Oregon, and California (2). These lands bear 98 per cent of the nation's virgin timber. The western forests are notable for the presence of such commercially valuable species as Douglas fir (*Pseudotsuga menziesii* (Mirb.) Franco), ponderosa pine (*Pinus ponderosa* Laws), sugar pine (*Pinus lambertiana* Dougl.), western white pine (*Pinus monticola* Dougl.), and redwood (*Sequoia sempervirens* (D. Don) Endl.), not one of which occurs elsewhere in the United States. Some of these forests, notably the Douglas fir, spruce-hemlock, and redwood types of western Washington, Oregon, and northwestern California, have growth rates probably equal to any in the northern hemisphere. In contrast, some forests of the ponderosa pine type that occur in localities having low precipitation grow very slowly, but if allowed to mature for several centuries produce timber of high value. About two thirds of the western commercial forest area is in public ownership, mostly federal. The privately owned lands, constituting those selected out of the public domain prior to the establishment of the national forests, are generally more accessible and productive.

---

[1] Prepared for Symposium on *Natural Resources of the West.* Joint Session of A.A.A.S. Section F and the Western Society of Naturalists, Berkeley, Calif., December 28, 1954.

The commercial forests of the West are currently producing nearly 40 per cent of the nation's sawtimber, and timber production is, of course, one of their principal uses. The other values inherent in these forests, however, are of critical importance to the West, and must be given due weight in management practices. I refer primarily to water yield and the production of forage that provides grazing, mostly during the summer season, to substantial numbers of domestic livestock. The use of commercial forests for recreation, including hunting and fishing, does not basically affect management practices.

The principal tasks that lie ahead in making the western commercial forests fully productive of timber can be grouped under four general objectives: protection; conversion of virgin forests into well-stocked growing stands; prompt establishment of adequate regeneration; and improvement in quality and yield of wood.

The first objective, protection, is designed to decrease losses from fire, insects, and disease. The western forests suffer an annual loss of more than one billion board feet of timber from these causes. About one fourth is due to fire, and three fourths to insects and disease. This loss can never be entirely prevented, but it can be materially reduced.

Reduction of fire losses will be achieved by fire prevention, largely through public education; increase in specialized, highly skilled personnel; development of improved equipment; and aggressive research upon the nature of and relationships between the ground and atmospheric conditions affecting forest fire.

Progress is being made in reduction of losses from parasitic insects. New, powerful insecticides, applied to large forest areas by airplane, are proving increasingly efficaceous in controlling certain types of insects. Other types are being attacked by silvicultural methods providing environments favorable to tree vigor and unfavorable to the insects.

The struggle to decrease losses from the many fungus diseases attacking the forest is seemingly never ending. Losses caused by wood-rotting fungi are often heavy in virgin forests containing a large proportion of old trees. As these virgin forests give way to young, vigorous stands of second-growth timber this type of damage will decrease. Silvicultural methods seem promising for the control of some diseases attacking juvenile trees.

A new approach, the genetic development of tree forms resistant to insects and fungi, is now assuming importance. Current research is giving encouraging results.

Attainment of the second objective, conversion of virgin forests into well-stocked, growing stands, is necessary to assure permanent production of wood products. Only a system of forestry which provides for the growing and harvesting of successive timber crops can guarantee a continuous timber supply. The virgin forest is a natural heritage of great value. To the commercial forester, however, it can only be considered as the current crop of timber, to be harvested and replaced by the man-cultured young forest that will, when mature, constitute the next timber crop. In commercial forestry the tree farm will supplant the forest primeval. It is recognized, of course, that areas of virgin forest required for scientific study and for recreation will be reserved and are then, by definition, no longer considered as commercial forest.

Effective conversion of a virgin forest into a vigorous, well-stocked second-growth stand is a vexatious and difficult matter. Methods of harvesting the virgin timber have markedly different effects upon the amount of regeneration and the promptness of its appearance. The relative merits of clear cutting and selective cutting of virgin stands are frequently debated by foresters. Both doubtless have their place in the western forests. In the dense stands of the Douglas fir and spruce-hemlock types in western Oregon and Washington, clear cutting in small enough blocks to assure adequate seed dispersal from surrounding trees is proving effective. In many of the thinner ponderosa pine forests, where every acre may bear trees from seedling size to merchantable veterans, selective cutting often proves more advantageous.

To secure the third objective, prompt establishment of adequate regeneration on cut-over areas and in poorly stocked juvenile stands, is a difficult task at best in many parts of the West. A substantial portion of the western commercial forest area is characterized by high temperatures and scanty precipitation during much of the growing season. These conditions militate against the establishment of sufficient numbers of coniferous seedlings to form an adequate stand. The density of many virgin forests indicates that in the past nature has coped with the problem successfully. But nature is content to spend many decades in developing a dense forest; man is not. Many of our best virgin forests may well have resulted from a fortuitous sequence of such favorable circumstances as the sudden destruction of an old forest by fire during the late summer of a good seed year, followed by a year of temperatures and summer precipitation particularly favorable to the establishment and survival of forest tree seedlings. But commercial forestry cannot await the operation of so uncertain a process, so other ways must be found to secure prompt regeneration.

Planting, as a solution to the problem of uncertain natural regeneration, has been only partially successful in the West, because adverse field conditions affect planted tree stock and natural seedlings alike. Also, it is a costly process. Nevertheless, it has certain advantages over natural regeneration. Where successful, it assures a stand of the desired species, with the trees properly spaced to produce high yield at maturity. And it is only by planting that trees genetically improved by breeding can come into use.

It is probable that forest planting in the West could be much more successful, despite adverse field conditions. Study of the methods commonly used in seed collection, nursery growing of the planting stock, and its outplanting in the field leads me to the conclusion that practices consistent with the principles of the plant sciences are frequently sacrificed in order to keep costs at a minimum. The cost accountant seems able to outvote the plant scientist in determining procedures. Analyses of current planting methods by plant scientists and more research on problems not yet solved would, I am sure, materially increase the degree of success of planting.

Direct seeding, in contrast to the planting of nursery grown stock, offers some promise for artificial regeneration. Two methods are being tested: broadcasting of seed from airplanes and planting of the seed at regularly spaced intervals. The greatest deterrent to either method is the presence of rodents that eat the seeds or the seedlings. Temporary heavy reduction of the rodent population on the seeded area by the broadcasting of poison bait may be the answer to this problem.

The fourth objective, improvement in quality and yield of wood, opens up new and interesting possibilities in forestry. It holds the promise of increasing timber production by application of the same scientific knowledge that has increased farm crop production so markedly. There are two possibilities: tree improvement for greater yield and better quality, and soil improvement for greater yield.

In the United States, forest tree improvement is a new and rapidly developing field of research from which material benefits can be expected. Its object is the development of tree forms specially suited to local conditions, including resistance to the insect and fungus pests of the particular region; good form and growth rate; and special wood qualities designed to meet the requirements of special uses. Two general methods of forest tree improvement are being used: selection of superior races and phenotypes, and development of new forms by breeding.

Provenance studies, by which races of widely distributed species are tested under a variety of environmental conditions, are useful tools in selection of races and are being widely used. In most cases a race is better suited to its own environment than to any other, but tests have demonstrated valuable exceptions.

A practical method for selection of superior phenotypes is by securing seed from groups of superior trees, carefully selected for desired characteristics and sufficiently isolated to prevent cross-pollination from other, poorer forms. This can be accomplished by harvesting or roguing out the inferior trees on an area containing a goodly number of superior individuals and by removal of all trees of the same species over a surrounding area of sufficient size to effect the necessary isolation. Cross-pollination thus occurs only between superior trees.

Increasing evidence indicates that the continued, persistent selection of superior races and phenotypes will bring a degree of improvement of forest growing stock that justifies its application to forestry. While admittedly slow, improvement is cumulative in effect. Selection has the advantage of simplicity in comparison with tree breeding and can be applied by foresters who do not have specialized knowledge of plant genetics.

Forest tree breeding, however, holds the greater potentiality for forest tree improvement. Forest trees are one of the few widely used kinds of plants which have not been materially improved by genetical means, and the potentialities for their improvement are as great as those for any of our agricultural crops. Over the past century a number of natural forest tree hybrids were described and a few artificial hybrids were produced, but no attempt was made to apply the information to practical forestry. It is only in the last two decades that forest genetics has been recognized as a distinct branch of plant genetics, with its own objectives, methods, and increasing body of literature.

In the United States, breeding work on many forest tree species is now being conducted by numerous universities and by federal, state, and private research institutions. The work is largely exploratory in nature, in that very few artificially bred tree forms are old enough to permit evaluation at maturity. A large number of hybrids are being produced, mostly interspecific, but with an increasing number of intraspecific crosses between well-defined races of several species. Some of these new forms indicate in the juvenile stage that desirable traits of the parents can be brought together in the F_1 generation. A few hybrids indicate true heterosis with attending advantages of rapid growth. A number of the more promising hybrids are now undergoing large-scale field tests, generally in the form of comparison with the parent species. The breeding work is developing better knowledge of species relationships within several important genera, which will facilitate future development of new forms.

One of the greatest needs is for more research of a fundamental nature to provide tree breeders with information which will make their work more effective. Physiological and genetical studies of vegetative reproduction, flowering, growth, and wood structure of forest trees, and evaluation and measurement of the range of genetic variability of important timber species and their races are examples. Recent and valuable work by Pauley and Perry on ecotypic variation (3) and Mirov on the gum turpentines of pines, discussed in more detail later, are examples of the kind of research needed.

In the western states most of the work in forest tree breeding has been conducted by a single organization, the Institute of Forest Genetics at Placerville, California, a branch of the California Forest and Range Experiment Station, U.S. Forest Service. The Institute has made no attempt to cover the entire field of forest tree improvement, but has limited its work to breeding and related studies of species within the genus *Pinus*, one of the most important and valuable genera in the West. This specialization has brought notable progress within its narrow field. There remains, however, the need for work on other genera.

The Institute's principal work has been the production of pine hybrids. Since the inception of its breeding program in 1927, some 67 pine hybrids have been developed. Several exhibit marked heterosis, a phenomenon seemingly most apt to appear in the product obtained by crossing two closely related species of widely separated occurrence. An example is the hybrid *P. monticola* Dougl. × *P. strobus* L., which greatly exceeds either parent in growth. Another hybrid, thus far exhibiting satisfactory form and growth rate, seems to possess the very high resistance of one parent to a specific insect parasite. This hybrid, *P. jeffryi* Grev. & Balf. × *P. Coulteri* D. Don, has the commercially desirable form of *P. jeffryi,* is superior in growth to that parent, and evidently possesses the extreme resistance of *P. coulteri* to the reproduction weevil, *Cylindrocopturus eatoni* Buch., a destructive parasite occurring on young trees of several pine species, including *P. jeffryi.* The hybrid of *P. strobus,* susceptible to white pine blister rust, *Cronartium ribicola* Fischer, and of *P. griffithii* McClelland, highly resistant to the rust, has undergone seven years of exposure to the disease with no evidence of infection. These examples are indicative of the progress possible through specialization of forest tree breeding to a single genus.

The Institute's investigation of the chemistry of gum turpentines of pines, conducted by Dr. N. T. Mirov, has proved to be of special value. The study has included the turpentines of most of the pine species of the world for which previous analyses were not available, and analyses for the species of the United States and Canada are now practically complete (4). It has been found that the turpentine content of any species, or in some cases of a well-defined race, is uniform, irrespective of environmental conditions. Hybrid species contain all of the turpentines of both parents, but in other proportions. The resistance of the hybrid *P. jeffryi* × *P. Coulteri* to the reproduction weevil is seemingly associated with the presence of an oleoresin originally occurring in the resistant *P. Coulteri* and absent in the susceptible *P. jeffryi.* Further, the degree of resistance appears to be related to the amount of the oleoresin in the hybrid form, as indicated by the fact that the F_1 hybrid, containing more of the oleoresin, is more resistant, and the back cross onto *P. jeffryi,* containing less of oleoresin, is less resistant. These facts justify the hypothesis that the oleoresin is the cause of the resistance. Classification of pine species based upon their turpentines provides a better basis for determining species crossability than taxonomic systems based upon macroscopic plant characters (5). These results from the study of gum turpentines illustrate the value of fundamental research to provide the tree breeder with information basic to his work.

The yield of timber from a forest crop is directly related to the fertility of the soil upon which it grows. The possibilities of increasing the yield on poor soils are limited. The need for soil protection and soil improvement will become more evident as forest geneticists develop faster growing tree forms that will make severe demands upon the supply of plant nutrients available in the soil.

Forest soils can become impoverished and, in fact, can be made unsuitable for forest tree growth in several ways. Repeated, severe forest fires will adversely affect the structure, physical condition, and chemical and biological nature of forest soils. They will cease to possess the combination of properties by which we characterize forest soils. Natural processes, involving the recapture of the site by arborescent vegetation, will finally reestablish the forest, but a long period of time is often necessary.

Comparable damage to forest soil can result from practices causing topsoil losses by erosion. Logging and road construction on steep slopes, particularly when accompanied by almost complete destruction of the vegetative cover, often cause heavy erosion. A degree of soil disturbance that merely loosens and cultivates the topsoil without heavy erosion may favor forest regeneration. But disturbance that results in exposure of heavy, compacted subsoil makes regeneration difficult.

Forest soil improvement has hardly progressed beyond the stage of theory in the United States. We have not as yet accepted the idea that soil fertilization is physically or economically practicable, except in cropland soils. Progress in forest soil fertilization in other countries will, I hope, stimulate research here. In Australia application of phosphates to forest soils has resulted in an increase of tree growth that may make the practice economically desirable, and application of small amounts of zinc to Monterey pine seedlings has brought astonishing results (6). Research on fertilization of western forest soils, including determination of its economic feasibility, is a new and open field of study. Many forest soils in the West are deficient in nitrogen and phosphorus, and little is known of the effect of adding these elements. Also, a study of micro-element deficiency might bring results of practical value.

The water demands of the West, to meet the increasing domestic, industrial, and agricultural needs of the growing population, are constantly expanding. The commercial forest areas, together with the high mountains, are the source of this water. No matter how far it must be transported to meet the needs of population centers, its invariable sources are the mountainous areas of high precipitation. Forest management, therefore, must do its share to maintain and, if possible, augment water yield.

In a thoughtful and informative paper, Dr. E. A. Colman (7) recognizes three ways by which forest management can contribute to water yield: protection, repair, and improvement of forested watersheds. Protective measures are designed to maintain a favorable water flow and low erosion rate equal to those of the virgin forest. They include fire protection; careful location, construction, and maintenance of roads; and the use of logging methods least damaging to the structure of the forest floor, the surface accumulation of organic matter above the mineral soil.

Repair of damaged watersheds consists of such measures as immediate revegetation, preferably with valuable forest species, of forest lands denuded by fire; prevention of erosion on denuded lands by construction of small dams; soil stabilization on areas disturbed by logging; and clearing of stream channels choked with logging debris.

To quote Dr. Colman, "The objectives of water yield improvement are to reduce streamflow in winter and early spring when supplies are greater than needs, increase the low flows of the dry season when water is in short supply, and decrease evaporative water losses in ways that will increase the quantity of usable water available downstream." Past experiments indicate that the desired regulation of streamflow may be accomplished by timber harvesting methods favorably affecting snowpack, consequent rate of snowmelt, and direct evaporation of water from snow. A recent experiment in Colorado indicates the value of timber cutting in some pattern of strips or blocks that lessens the tree crown surface of the forest, thereby permitting more snow to reach the ground, yet providing the most possible shade. The effect is to decrease snow evaporation in the tree crowns and to retard, by shading, the rate of snowmelt on the ground. Similar experiments are needed in other parts of the West where other conditions exist.

Of the 17½ million acres of commercial forest land in California, some 10 million acres, or 57 per cent, produce forage utilized by domestic livestock, game animals, or both, and some such proportion probably holds for all of the western states. Some of this area has permanent grazing value but most of it can be grazed only during limited periods in each forest rotation. A substantial part of the forage occurs in the open meadows frequently found in the forest. Wherever occurring, forest forage must be protected from over-grazing, and depleted ranges must be repaired, in order that soil losses, destructive to timber, water yield and forage alike, may be prevented.

There is at present widespread feeling that western forest management practices for timber, water, and forage production differ so greatly that they are in serious conflict. If, however, their mutual interest in common objectives is weighed against their differences, I see no basis for real conflict. All three call for protection from fire, except where used under control as a tool of resource management, and from other destructive forces. All recognize the need for prevention of accelerated erosion and loss of topsoil, and for prompt revegetation of denuded areas. In all cases, sound management practices to attain these ends will, perforce, be based upon the economically feasible application of the plant and soil sciences and other disciplines such as hydrology and climatology. Recognition of this broad area of common interest will relegate conflict to the level of differences which can be settled by adjustment.

Predicted increases in the population of the western states will make demands upon the commercial forests of the region which will justify a more intensive degree of management than is now being practiced. Much more knowledge than is at present available will be needed, and many difficult problems will have to be solved. All that can now be said is that no end to the development of forest management practices can be foreseen. As new technologies develop new products, the kinds of raw materials needed from the forest may change, with consequent changes in management objectives. The quest for knowledge to meet increasing demands for forest products, old or new, will require an expanding and continuing research effort in which western universities and other research institutions will have an important part. The combination of continued research and conservative management will maintain throughout the future the productivity of the western forests.

REFERENCES

1. Society of American Foresters
   1950. Forestry Terminology.

2. United States Department of Agriculture—Forest Service
   1946. Gaging the Timber Resource of the United States.

3. Pauley, S. S., and T. O. Perry
   1954. Ecotypic Variation of the Photoperiodic Response in *Populus*. *Journal of Arnold Arboretum*, XXXV:167–188.

4. Mirov, N. T.
   1954. Chemical Composition of Gum Turpentines of Pines of the United States and Canada. *Journal of the Forest Products Research Society*, IV:1–7.

5. Mirov, N. T.
   1953. Chemical Aspects of Diploxylon Pines. *Zeitschrift für Forstgenetik und Forstpflanzenzüchtung*, 2. Band. Heft 5.

6. Stoate, T. N.
   1950. Nutrition of the Pine. Bulletin No. 30, Forestry and Timber Bureau, Canberra.

7. Colman, E. A.
   1954. Water Control and Timber Management. *Proceedings of Annual Meeting Western Forestry and Conservation Association.*

PROCEEDINGS
OF THE
CALIFORNIA ACADEMY OF SCIENCES
Fourth Series

Vol. XXVIII, No. 12, pp. 425–439 February 17, 1956

THE CONSERVATION AND FUTURE DEVELOPMENT OF WEST COAST MARINE RESOURCES[1]

By
RICHARD VAN CLEVE
Director and Professor
School of Fisheries, University of Washington

As a result of the last war we have had closer contact with backward nations where deficient diet is the rule. This contact has been maintained through the work of the United Nations assistance groups with many nations in the less-developed areas of the world. All these have served to emphasize the growing disparity between rate of population increase and the present apparently limited capacity of our land masses to increase their productive capacity indefinitely. The gloomy predictions of Malthus appear to be brought nearer to realization by the success of medical science in reducing the effects of disease and raising infant as well as adult survival rates. Anticipating the difficulty of feeding the future world's population the search for new sources of food has been intensified.

In surveying potential sources of large quantities of food one is always struck with the fact that whereas the oceans occupy almost three quarters of the earth's area, they produce at present only ten per cent of the world's total protein. With some areas obviously underfished and others apparently capable of a much higher production, speculation has not only embraced a possible increase in the production of fish but has included suggestions of the direct use of plankton which eventually is converted into fish with a considerable loss of efficiency (Reay, 1954). Others have suggested that work should begin on the development of methods of actually farming the sea (Daniels and Minot, 1954). The latter would be based upon the known large quantities of nutrient materials in the sea that are made available for the use of growing plants and animals only where the ocean current systems bring them into the euphotic zone. Experiments on the fertilization of enclosed arms of the sea (Raymont, 1947) and with artificial propagation

---

[1] Prepared for Symposium on *Natural Resources of the West.* Joint Session of A.A.A.S. Section F and the Western Society of Naturalists, Berkeley, Calif., December 28, 1954.

Contribution Number 12, University of Washington, School of Fisheries.

of marine fishes have been tried with some success in Europe (Dannevig, 1951) and salt marshes have been used for some time in Asia for the culture of *Chanos chanos* or milk fish; but the actual use of the rich mineral deposits held in the ocean depths seems to be a remote possibility at the moment.

To one who has had experience with the collection of plankton on the high seas, the harvest of amounts that would contribute significantly to our food supply seems impractical even if ways could be found to utilize it directly. For the present at least, it appears to be much more economical to permit the fish, which are especially fitted for gathering and converting the plankton into palatable proteins to make this harvest for us. The most promising line of attack in this direction appears to be the rumored search for methods of cultivating phytoplankton. Such a process might produce large quantities of desirable forms eliminating the difficulties of sorting as well as capture.

Taking a more practical view, the United Nations conference on natural resources held at Lake Success, N. Y., in 1949, considered methods of increasing the production of fish from the sea immediately, to fill the current needs of food-deficient areas. It has been estimated that the total world production of fish in 1950 was 25,000,000 metric tons. Of this just six nations in the northern hemisphere produced 61 per cent. Japan alone before the last war produced 38 per cent of the world's total (Harold Thompson, 1951). A greater disparity is shown by the 98 per cent produced in the northern hemisphere as compared with 2 per cent in the southern. That is, the more highly developed fisheries and consequently the greatest concentration of fishing effort are at present associated with the most highly industrialized countries in the northern hemisphere. In this region fish are produced by several countries far in excess of their own needs and have become an important commodity in their foreign trade. Consideration of all the possible sources of fish known to the participants led the United Nations conference to anticipate increases of from 22 per cent (H. Thompson, 1951) to 36 per cent (F.A.O. United Nations, 1953) by 1960 over the 1950 level. LeGall (1951) stated that present needs are double the amount of fish now produced and that by 1960 they will be three times this figure or about 75,000,000 metric tons. The discrepancy between the growing need and predictions of what might be taken are striking and the greatest need for this increase is in the most densely populated areas where living standards are low and diets are especially deficient in protein.

At the present time the fishing industry does not hold such an important position politically or economically in the United States as it does in other countries with comparable levels of fish production. For example, total production of all meats in this country amounted to about 23 billion pounds in 1952 whereas fish production totaled about 4 billion pounds in the same year, of which approximately 25 per cent was used for food. Per capita consumption of fish in the United States is only about 11.5 pounds (1948) per year as compared with three times that amount, 33.3 pounds in the United Kingdom, 83.3 in Japan, and 59.3 in Norway (Tressler and Lemon, 1951). Another situation that affects our fisheries adversely is that several of our allies are deficient in other natural resources and now use fish as one of their export products which help to maintain their balance of trade with the United States. The present need to help our allies may require relaxing tariff restrictions on such products, which would aggravate the competition our fisheries must face from countries in which production costs are low compared to ours.

However, the fisheries of the United States must increase their importance in the future, both as a source of living to those associated with them and also as a source of protein food. Our population growth is following the same course as that of other countries, and is continually increasing the ratio of population to acres of food-producing land. Like other countries, we will eventually have to look to the sea for more of our food. Even now the United States is one of the best markets for higher-priced fish products and the sale of other fish could be greatly expanded if increased production efficiency widened the price differences between fish and competing products such as meat. Additional sales would undoubtedly develop if our fisheries industry could learn to market top-quality material in as pleasing form and good condition as prevails for most meats. With a growing interest in technology and marketing, these developments can be expected. Moreover, if the potential demand of large populations, now prevented by poverty from buying food, can be released, the full productive capacity of the fishing fleets of the entire world will be required.

In spite of the relatively low position of fisheries in the United States, we are now the second greatest fishing nation in the world in total production. Of the total fish produced in this country an average of 43.4 per cent came from the West Coast and Alaskan areas over the period of 1940 to 1951. For this, as well as for other reasons that will be made apparent below, our Pacific Coast fisheries can be expected to play an important role in the future. We should therefore examine their present condition and attempt to foresee what possibilities they offer for future production.

Present Condition of West Coast Fisheries

The existing fisheries of the West Coast of the United States and Alaska do not on the whole present an optimistic picture. In Alaska, the salmon fisheries have completed a second poor season with a pack of slightly over 3,000,000 48-pound cases of canned salmon as compared with 2,900,000 cases last year which in turn may be compared with an average of almost 4,000,000 cases for the last 10 years. The trend has been downward since 1934. Off the coast of California the sardine fishery has been practically nonexistent for two years and the Pacific mackerel seems to be following the same path. The salmon fisheries of the Columbia River in 1952 and 1953 showed signs of further decline beyond the drop that occurred in 1943.

In contrast, however, the halibut fisheries under the International Pacific Halibut Commission and the sockeye of the Fraser under the control of the International Pacific Salmon Fisheries Commission are increasing. The other major West Coast fishery, the California tuna industry, is suffering primarily from economic competition with other tuna-producing countries.

Our West Coast fisheries therefore present a variety of problems the solution of which will determine the extent to which we will realize their full potentialities. They range from the need for expansion and stabilization of some fisheries through the combined efforts of fisheries biology, hydrography, and exploratory fishing, to the obvious need for fisheries management of some sort in several declining fisheries. They include the problems of adjusting the uses of water for power and irrigation to the needs of the anadromous fishes, as well as the need for development of a basis for handling oceanic fisheries problems that arise from international competition for the fisheries of the high seas. They also involve the development of more efficient methods of fishing and of handling, processing, and marketing, as well as conserving and possibly culturing our fishes.

It is not surprising that the general picture of the present condition of our fisheries has become confused by a combination of economic and biological factors that have not always been well identified. This confusion is understandable in view of the difficulties of studying marine fish populations which are not subject to direct observation. Problems associated with the measurement of productivity of certain areas or fish stocks so far have not been susceptible to controlled experimentation and their study has necessarily been confined to field observations which, even though they may be well designed, still leave many essential variables unmeasured.

The burden of solving the problems of conserving, developing, and ensuring the highest perpetual yield of our fisheries falls on the shoulders of our fisheries biologists. The purpose of fisheries biologists should be to determine the relationship of fish populations to the fisheries that utilize them and if necessary, either to discover methods of adjusting the fishery to the productive capacity of the fish population or to develop techniques of increasing productivity to satisfy the needs of the fishery. Unfortunately, adjustments have sometimes been attempted without knowing the relation of the fishery to the fish. In other cases it has been maintained, again without convincing evidence, that natural causes control the size of the fish populations and that adjustment of the fishery would serve no purpose. Complete and careful examination of all published data on these problems is not possible here, but the resolution of opposing views on this point will probably control the course of much fisheries work in the near future.

Our principal West Coast fisheries may be divided roughly into three types according to the nature of the species involved and of the problems associated with their productivity. These are first the oceanic fisheries, primarily for the various species of tunas. In a second group are the coastal fisheries which include such species as the sardines, mackerel, anchovy, rockfish, halibut, and other bottom fishes. The third group includes the anadromous fishes which in commercial value and volume are dominated by the salmon. The most valuable fisheries are the tuna and salmon although the largest in volume was that for the sardine.

The condition of each one of these major fisheries is different, as are the problems and possibilities for their future development and use, although some nonbiological problems affect them all. Most noteworthy of these is that of territorial waters and the problem of ownership of marine fisheries. Although this may be considered primarily a legal and political problem, most political boundaries do not agree with biological boundaries and the eventual solution of even these problems will have to be harmonized with the basic biology of our fisheries. For this reason international treaties have been created to solve some of the more immediate international problems of conservation and use of the halibut, salmon, tuna, and other fishes. These problems are made more difficult by the fact that marine fishes are taken in offshore waters which traditionally have been considered open to men of all nations. Major adjustments in some recent concepts of territoriality and national rights will be necessary for satisfactory solution of either the biological or political aspects of our marine fisheries problems.

Oceanic Fisheries

Those problems which are important in oceanic fisheries are the definition of the biological limits of stocks, some of which appear to range the whole Pacific, the determination of potential yield of these wide-ranging stocks, and adjustment of the fishery to it. If our fishermen are to share in this resource we will have to determine where these oceanic fishes can be taken in commercial quantities and will have to develop fishing techniques that will enable our men to compete with the government-supported fishermen of other countries. In this field for the first time in history we find fishermen, fisheries biologists, and physical and biological oceanographers working together in the well co-ordinated program of the Pacific Oceanic Fishery Investigations which operates out of Hawaii.

The results of this program are striking. The existence of large stocks of tuna in the north equatorial Pacific Ocean has been established, and the proven ecological relationships between tuna and the ocean currents indicate the possibility that other stocks of tuna exist in the South Pacific, Atlantic, and Indian oceans. The oft-stated claim of biologists that tropical ocean waters are generally unproductive seems to have been pretty well exploded, though apparently it has not yet been abandoned. The possibilities of developing large tuna fisheries appear to be certain and their realization will depend primarily on developing more economically feasible methods of capturing and preserving this most perishable food far from home ports.

The work of P.O.F.I. is now being extended north of the Hawaiian Islands and will probably be co-ordinated with other programs, including that of the North Pacific Fisheries Treaty between the United States, Japan, and Canada. One result should be the expansion and stabilization of our West Coast albacore fishery, which has so far been confined merely to the eastern fringe of the range of that species.

The need for conservation of our oceanic species has already been indicated by the Inter-American Tropical Tuna Commission. It has found that probably the relatively local stock of Yellowfin tuna fished by the California fleet off the Pacific Coast of Central America and northern South America has reached its maximum level of yield and will not stand a greater take. This does not seem to hold for the Skipjack tuna fished in the same areas which appears to be capable of an even larger production than its present 80 to 125 million pounds per year (Pacific Fisherman, November 1954, page 53). These conclusions must be accepted with reservations until the extent and magnitude of the tuna stocks involved are evaluated. Such a survey will present great problems and will require a much greater expenditure of funds and energy than has so far been available.

The most sensible approach to conserving these oceanic fishes appears to be through international treaties, several of which have already demonstrated their soundness and efficiency. For some years the United States tuna fisheries have faced problems arising from differing interpretations of the extent of territorial waters, and from the controls certain countries have imposed on fisheries where both the bait and tuna fish are caught. In 1945 President Truman proclaimed a new policy for conserving oceanic fisheries (Proclamation 2668, 1945). Subsequently Peru, Chile, and Ecuador have given force to their own interpretation of this act by proclaiming ownership of the sea to a distance of 200 miles from their coasts. While the United States, as well as other countries, has not recognized these claims, there seems to be a move toward extending territorial waters, especially by smaller nations off whose shores the ships of other countries fish. Some answer to these claims of extended territorial controls must be found which will protect both the rights of the adjacent countries, and of the fishermen who have developed the fisheries, and at the same time will protect the fish.

Coastal Fisheries

Our coastal fisheries are concerned with a wide variety of species and fishing techniques as well as of problems. In value and volume the sardine (*Sardinops caerulea*) fishery has dominated this field, which includes the now-famous halibut fishery of the North Pacific. The condition of these fisheries cannot be examined in this brief survey but may be indicated by an outline of three typical situations.

Sardine Fishery

The sardine fishery of the Pacific Coast did not begin to develop until after World War I and only grew to its full volume after 1930 with the development of the fish meal and oil markets. Heaviest landings occurred in the season of 1936-1937 when offshore floating reduction plants had added their processing capacity to that of the shore plants. After the elimination of the floating plants during the next few years, the capacity of both the shore stations and of the fishing fleet increased; but even though the fleet increased steadily in efficiency during these years, the landing record of 1936-1937 was never again equaled. A decline in average catch per boat began in the 1935-1936 season but it seems to have been relatively stable from 1937 to 1945, after which it again dropped sharply (Clark and Daugherty, 1950). This irregular decline in catch per boat was accompanied by the progressive disappearance of the older age groups and thus the fishery, first from the coast of British Columbia in 1946, then from Washington waters in 1948, and from Oregon in 1949. This was finally followed by the disastrous years of 1951 and later off San Francisco and Monterey. Although production continued in 1951 and 1952 off San Pedro with a greatly increased fleet, which was augmented by boats which had followed the fishery southward, even this last stronghold of the sardine gave out in 1952 and 1953. By this time even the most optimistic should have begun to wonder if the sardine schools had become scarce and to doubt that they had only moved farther offshore or into deeper water where boats and nets could not find them.

The decline in the fishery was associated with a deficiency in the numbers of young fish. The last very-large-year class was produced in 1939 (Felin and Phillips, 1948) and the production of young since then has not been sufficient to maintain the fishery. Because of the lack of large year-classes, and also because of correlations that have been found between ocean conditions and size of sardine year-classes, some have been led to deprecate the role played by the commercial catch in producing the present situation. It is interesting that in a brief discussion of this problem Schaefer (1954) was able to show, on the basis of a theoretical relationship between fish abundance and fishing yield, based on Verhulst's equation of growth, that the fishery had been a primary factor in the decline of sardine abundance. Unfortunately, although much money and effort have been expended investigating the Pacific sardine, no one agency has had sufficient funds or authority to develop a broad enough program to cover the entire range of the species, which extends from southeastern Alaska to Mexico. As a result, many obscure points still remain in the sardine picture which even the present augmented efforts are unlikely to clarify.

There is no doubt that major fluctuations in abundance of sardine have occurred in the past as a result of the varying survival of individual year-classes. However, it seems presumptuous to ignore the effect that the great reduction in abundance of mature fish, which formerly supported the fishery north of California, must have had on the production of young.

Even though variations in abundance may occur naturally, it is probable that the level around which the sardine population varies has been lowered by the fishery until in the last few years the lower points in the cycles of abundance have become disastrous for the industry. It is also probable that with flexible control of the fishery these lower levels of abundance might be raised by the maintenance of a larger residual population. A larger population would also increase the probability that abundant year-classes would be produced.

Bottom Fisheries

A different type of problem is encountered in the coastal fisheries for bottom-dwelling species. While some species such as the halibut are now fished at about the limit of their productive capacity, there are other species which could produce much larger quantities of fish, especially along the coast of Alaska. An example is the true cod, *Gadus macrocephalus.* This species is taken along the entire coast from Oregon to the Bering Sea where in years past a considerable fishery was developed for salt cod. As the market for this product disappeared, the Bering Sea cod fishery had ceased to exist. In the last two years, however, the industry has introduced fish into the market in a new form known as "fish sticks." This new product has increased rapidly in popularity and has created a new market for fish which are suitable for conversion into this form. Cod seems to be ideal for this purpose and as a result, landings have increased with the demand until this year an estimated 12,000,000 pounds have been landed in Washington alone as compared with 7,000,000 pounds in 1950. Obviously the fish are available to the fishermen and all that is required is a market that will purchase their catch for enough to make operation worthwhile. A similar increase in rockfish landings resulted from the increased popularity of "Ocean Perch" filets in the last few years.

The opposite picture is seen in the rapid rise and fall of the shark fishery off this coast. Beginning about 1940 the demand for vitamin A rose rapidly. Dogfish shark or grayfish were found to have liver oil several times richer in this vitamin than codfish-liver oil. The demand was increased by the wartime closure of Norway as a source of the latter. Another species of shark—the "soupfin," *Galeorhinus zyopterus,* was found to yield even greater quantities of vitamin A than the dogfish. Landings of these sharks rose so rapidly with the price of the oil that Ripley (1946) found evidence of a sharp decline in soupfin abundance by 1943. With the development of synthetic vitamin A after the war and cheaper foreign sources of fish oil the American landings declined and the fishery has now been practically abandoned. Information obtained from fishermen shows that both soupfin and dogfish sharks are now abundant off our shores but with no market for either the oil or carcasses, except for reduction, these fish are generally avoided if possible or are discarded at sea. Landings fell to 1,287,000 pounds in 1953 as compared with a high of almost 53 million pounds in 1944.

There is a large potential supply of these as well as several other species, but some method must be found of using them that will permit an adequate return to the fishermen. If such a market could be developed and a good price offered it has been estimated that a stable production of between one and two billion pounds could be produced each year from all of the bottom species (Chapman, 1943).

With limited markets and an abundant supply of raw produce it is not surprising to find wasteful practices where the fishermen are sent out with orders to bring in limited amounts of only those species the processors can profitably market at that time. Catch limits are normal in our trawl fisheries and combined with regulations which forbid the use of food fish for reduction purposes result in the discard of as much as 70 per cent or more of the total catch taken in trawls (Pruter and others, 1953). While some of the discarded fish are below minimum size limits set by state law in the state of Washington, many are of species that cannot be marketed at present. Such species as the ratfish, *Hydrolagus colliei,* and hake, *Merluccius productus,* though available in large quantities, have never been marketed on the West Coast except to reduction plants. Development of uses and consequently markets for fish that are now discarded would not only eliminate substantial waste; it would also avoid a possible disturbance of the interspecies balance, which might add to the strain already imposed on more valuable species by selective fisheries. The wasteful practices engendered by the lack of markets is evidence of the relatively undeveloped state of some of our West Coast fisheries, biologically, technologically, and economically. As a result of an abundance of protein and with a predominant indifference to fish as an article of diet, the productive capacity of our fishing fleet is not being utilized, and little incentive has been offered to our technologists as yet to develop uses for "nuisance" species. If survival of our fishing industry can be considered a worthwhile objective (and I believe it is one) conditions call for an intensified interest in technology to increase further the efficiency of our fishing, processing, and marketing.

Full utilization of the fishing fleets now in existence in the U.S. inevitably would raise the problem of management. The only two examples of successfully managed stocks of marine and anadromous fish are to be found on the North Pacific Coast of America. Both of these fisheries, the halibut and sockeye salmon of the Fraser River, were placed in the hands of international commissions and both operate under treaties between the United States and Canada. So much has been written concerning the outstanding work of the International Pacific Halibut Commission and the International Pacific Salmon Fisheries Commission that it will not be reviewed. In spite of the marked success of their management there still remain a few biologists who either maintain that these two outstanding examples are the result of a chance agreement of management practices with a favorable natural increase in stocks, or that these two examples are quite different from any other fisheries problem. These two successful cases of fisheries management do, as a matter of fact, differ markedly from most other attempts, in that a sound foundation of biological knowledge of the species involved was in each case accumulated before management was undertaken, and in the Fraser River before work was begun on the rectification of unfavorable environmental factors. In both fisheries, too, this sound background has been used as a basis for regulation and, so far as possible, a system of continuous checks on the biological results of these regulations is maintained. It may be predicted with confidence that both of these fisheries will continue to maintain a high level of production as long as regulations are soundly based and continuously readjusted according to constant observation of reaction of the stocks. It may be predicted just as confidently that neglect of that biological background will lead to the eventual failure to maintain the fisheries.

The success of these two "experiments" in fisheries regulation indicates that, with sufficient knowledge of our fish populations, a type of farming can be imposed upon our fisheries, in some ways comparable with present management of forests for continuous yield. Decisions as to kind or extent of knowledge that will furnish a sufficient basis for successful farming of this nature must not be warped by blind adherence to previously conceived hypotheses, either as to the need for management or the techniques to be used in determining this need.

Anadromous Fishes

The International Pacific Salmon Fisheries Commission has demonstrated that if the salmon are given free access to their spawning grounds, and if the fishery is regulated to permit adequate escapement of all parts and especially the peak section of each race, the runs can be rebuilt and maintained. No dams block access to the spawning grounds of the Fraser River Sockeye and the natural and artificial blocks to their movements have been removed. This condition is quite different from that found on most salmon rivers in the western United States, a typical example of which is the Columbia River. Recently publicized plans for dams on the Copper and Yukon rivers in Alaska portend that conditions like those on the Columbia may develop on all salmon streams.

The use of water for irrigation and power developed gradually on the Columbia until the growing industrialization of the Northwest and the increased need for power resulted in a great surge of dam building during the last twenty years. The gradual development had not been met with sufficient funds and staff to enable fisheries biologists to solve even the current problems, and people working in that field during the late twenties and thirties were fortunate to prevent the complete loss of most of our major West Coast runs. With the help of federal aid funds during this period, definite progress was made in screening irrigation ditches to prevent the loss of young salmon on their way to sea. Some progress was also made in building fish ladders to enable salmon to surmount dams but study of the basic biology and reaction patterns of both young and adults as well as of the details of fresh-water life history lagged behind, largely because of an enforced economy in appropriations for fisheries work acceded to by an uninformed public. The sudden increase in rate of dam construction as well as in the magnitude of projects sponsored by the federal government caught the fisheries biologists with neither sufficient facts to solve the problems which suddenly confronted them nor with sufficient funds to gather those facts.

One result of the struggle between power and irrigation interests on the one hand and fisheries interests on the other has been a gradual though very grudging acceptance of the fact that the fish do have a place in our rivers and that something should be done to save this major source of food. The principal problems of handling both upstream and downstream migrating salmon at dams were out of reach of the relatively small appropriations of the fisheries agencies until in 1951 when the United States Army Engineers agreed to support a program devised by salmon biologists of the Northwest in an attempt to find out how to adjust conditions at dams to the needs of the salmon. Participating in this program are seven different fisheries agencies in the Northwest. The program now includes the study of practically every phase of the design of the fish ways, the relation of height of dam to the probable success of salmon surmounting it, and the effect of flooding spawning beds, including a more thorough survey of the present location of spawning and of areas that will be flooded by proposed dams. The downstream migration period of the young of different species and their distribution in the streams and reservoirs are also being examined in different areas, so that it may be possible to apply new techniques being developed for guiding the young around dams or through safe passages and thus reduce losses that now occur in some turbines and at some spillways.

The success or failure of this program may well determine whether or not we will continue to have our major runs of salmon. Its importance may be appreciated if we consider that the Columbia River in 1883 produced 629,400 cases of chinook salmon which at present market prices would be worth over $23,000,000 (Pacific Fisherman Yearbook, 1954). During 1953 a total of only 151,000 cases ot all species of salmon were packed in this area.

The need for this work becomes clear when the life history of the salmon is examined. Omitting details and differences between species, all require unpolluted water of moderate temperatures (45° to 55° F.) in which to spawn, in which the eggs can develop, and the young can live and grow to migrating size. When this time is reached, the young must have free access to the sea where they put on the major portion of their growth. On reaching maturity the adults return to the same stream in which they were deposited as eggs and unless they have free access to that stream, or unless conditions very similar to their native stream are provided, that population of salmon will be eliminated. Success of the runs requires a sufficient area of suitable spawning gravel covered by clean cool running water, a sufficient area for rearing the young (in those species that spend a year or more in fresh water), and free access for both upstream and downstream migrants. To provide these conditions it will be necessary in some cases to modify or compromise some of the plans now outlined for the use of the streams for power and irrigation. So far most of the modifications and compromises have been made at the expense of the salmon.

Great cumulative losses in spawning and rearing areas for salmon have been suffered in streams of the West Coast of the United States. It has been estimated that between 50 and 75 per cent of the original salmon spawning grounds in the Sacramento-San Joaquin river systems have been lost to these species by impassable dams (Van Cleve, 1954). Some 70 per cent of the Columbia River watershed has also been lost (Washington State Department of Fisheries, 1947) and unknown but additional losses will occur as more sections of the river are flooded by dams now being built or planned for that stream. Every effort is being made to alleviate these losses, not only by attempting to eliminate or at least reduce the losses of adults and young at dams, but also by opening up productive stream areas previously unavailable to salmon because of natural blockades (Washington State Department of Fisheries, 1954) and further, by attempting to develop efficient methods of artificial propagation to counteract the continued loss of spawning areas.

The salmon versus dams problem is still far from solution but at least it is being attacked vigorously and on a sufficiently broad front that there is now a very good chance that at least a sustained though limited production of salmon can be anticipated in streams that are developed for other purposes.

CONCLUSION

Prospects are bright for obtaining a considerable increase in production of fish from the sea but the need for preserving the productive capacity of our currently heavily exploited stocks must not be forgotten. The combined efforts of fisheries biologists, hydrographers, and marine biologists should result in the development of potentially large oceanic fisheries but considerable technical improvements will be required to enable our fishermen to operate economically on these widely scattered stocks.

On the other hand, the development of adequate markets and more advanced and efficient marketing methods should result in the development of a large fishery along the west coast of North America on stocks which are essentially not now utilized. The best use of this fishing region requires some new means of using many species that cannot now be marketed.

With the full development of our West Coast fisheries it will be necessary to anticipate the need to develop conservation measures along such lines as have been proven so effective by the International Pacific Halibut Commission in their rehabilitation of the north Pacific halibut stocks.

The maintenance of our anadromous fish runs will involve the solution of the many problems encountered in handling upstream as well as downstream migrants at dams. Some means will also have to be found to compensate for spawning and rearing areas that will be, or have already been lost by flooding or by closing them to salmon by obstructive dams. Opening new streams by laddering impassable natural barriers and developing more efficient techniques of artificial propagation are both supplementing efforts to preserve the original salmon spawning grounds. Conservation measures similar to those used so effectively by the International Pacific Salmon Fisheries Commission can insure continued productivity of our salmon, provided the fresh water environment can be preserved.

Finally, settlement of the widely divergent views on ownership of deep sea fisheries must be reached if their development and conservation are to be successfully accomplished. Treaties appear to be the best means devised so far to protect and develop our fisheries through the co-operative effort of interested nations.

BIBLIOGRAPHY

CHAPMAN, W. M.

1942. The latest fisheries of Washington and Alaska. *California Fish and Game*, vol. 28, no. 4, October 1942.

CLARK, F. N., and A. E. DAUGHERTY

1950. Average lunar month catch by California sardine fishermen, 1932–33 through 1948–49. *California Division Fish and Game, Fish Bulletin* no. 76, 1950.

DANIEL, HAWTHORNE, and F. MINOT

1954. The Inexhaustible Sea. Dodd, Mead and Co., N. Y. 1954.

DANNEVIG, ALF. (United Nations Report)

1951. Propagation and transplantation of marine fish in Europe. *UNSCCUR Proceedings*, vol. 7, *Wildlife and Fish Resources*, 1951.

FELIN, F. E., and J. B. PHILLIPS

1948. Age and length computations, etc. *California Fish and Game, Fish Bulletin*, no. 69, 1948.

FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS

1953. Improving the fisheries contribution to world food supplies. *F.A.O. Fisheries Bulletin*, vol. 6, no. 5, 1953.

LEGALL, JEAN (United Nations Report)

1951. The present world problem of sea fisheries. *UNSCCUR Proceedings*, vol. 7, *Wildlife and Fish Resources.*

PACIFIC FISHERMAN YEAR BOOK, 1954, page 117.

PACIFIC FISHERMAN—November, 1954, page 53.

PROCLAMATION 2668

1945. Policy of United States with respect to coastal fisheries in certain areas of high seas, proclamation. Sept. 28, 1945. (Proclamation 2668) *Federal Register*, vol. 10, no. 193, October 2, 1945, p. 12304.

PRUTER, A. T., D. L. ALVERSON, J. JURKOVICH, and A. T. PALMEN

1953. Progress Report on Otter-Trawl Studies, April through June, 1953. *Marine Fisheries Investigations, Progress Report, Washington State Department of Fisheries*, April-June, 1953.

RAYMONT, J. E. G.

1947. A fish farming experiment in Scottish sea locks. *Journal Marine Resources*, vol. 6, no. 3, pp. 219–227.

REAY, G. A.

1954. The ocean as a potential source of world food supply. *Food Technology*, vol. 8, no. 2, Feb. 1954.

RIPLEY, W. E.

1946. The soupfin shark and the fishery. *California Division of Fish and Game, Fish. Bulletin* no. 64, 1946.

Schaefer, M. B.

1954. Some aspects of the dynamics of populations important to the management of commercial marine fisheries. *Inter-American Tropical Tuna Commission Bulletin*, vol. 1, no. 2, 1954.

Thompson, Harold (United Nations Report)

1951. Latest fishery resources and means for their development. *UNSCCUR Proceedings*, vol. 7, *Wildlife and Fish Resources.*

Tressler, D. K., and J. M. Lemon

1951. Marine Products of Commerce. 2nd Ed.—1951, Reinhold Publishing Company.

Van Cleve, R.

1945. Program of the Bureau of Marine Fisheries. *California Fish and Game*, vol. 31, no. 3, July, 1945.

Washington Department of Fisheries and Oregon Fish Commission

A program of rehabilitation of the Columbia River Fisheries, prepared by the Washington Department of Fisheries and Oregon Fish Commission. 1947.

PROCEEDINGS
OF THE
CALIFORNIA ACADEMY OF SCIENCES
Fourth Series

Vol. XXVIII, No. 13, 441–527, figs. 1–26 February 21, 1956

FULGOROIDEA FROM SOUTHERN CHINA

BY

R. G. FENNAH
Imperial College of Tropical Agriculture
Trinidad, British West Indies

This report deals with three collections of insects from China. The largest of these, comprising 241 specimens, was made by Dr. J. L. Gressitt in Szechuan and western Hupeh; the second (201 specimens) was made by Mrs. D. E. Wright in Chekiang, mainly in the neighborhood of Mokansan; the third (156 specimens) of material from other areas, chiefly in Kwangtung and around Hong-Kong, was made by various staff members of Lingnan University, including, in addition to the foregoing, W. E. Hoffman and E. R. Tinkham. The whole of the material, including all type specimens, has been returned to the California Academy of Sciences.

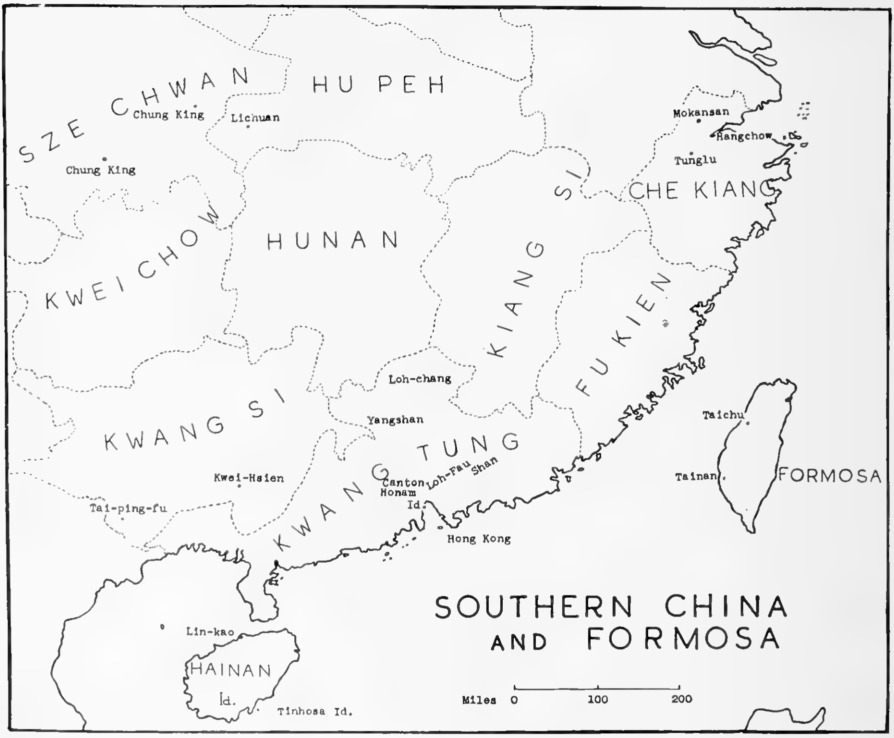
The writer tenders his warmest thanks to Dr. Edward S. Ross, curator of the insect collection of the Academy of Sciences, and to Dr. J. L. Gressitt for the privilege of studying this material. He also pays a well-merited tribute to the collectors whose personal efforts have made such a useful sample of this little-known fauna available for taxonomic study.

Collections of Chinese fulgoroid homoptera are too small and too scattered, and reports on them too insufficiently detailed, to afford adequate opportunity for any careful study of speciation in this important zoogeographical area. The object of the present report, therefore, has been limited to presenting the data in a usable manner; little attempt has been made to collate existing records, or to review and analyze the fauna.

Many facts of interest have emerged from a study of the present collections: the first record of *Ptoleria* in Asia north of the Himalayas; the substantial extension of the known distribution of *Nesopompe tsoui* Muir westward to Hupeh and northeastward to Japan; the establishment of new western limits for the distribution of *Kinnara fumata* (Mel.), *Los-*

bañosia bakeri Muir, *Diostrombus politus* Uhl., *Zoraida kirkaldyi* Muir, *Pamendanga sauteri* Muir, and *Megatropis formosana* (Mats.); of a new eastern limit for *Kamendaka nigromaculata* (Dist.), and a new northern limit for *Vivaha facialis* (Dist.). Two informative captures were those of *Caristianus ulysses* Fenn. and *Ommatissus lofouensis* Muir. The record of the former, described from Bornean material, in Yunnan, has not only extended the known range of this species, but has strengthened the case for assigning a new species of achilid, taken in the same general area, to *Zathauma,* a hitherto monobasic genus known only from Borneo. The identification of *Ommatissus lofouensis* has served to corroborate the accuracy of Muir's generic assignment, which was doubted by Melichar (1914: 214).

In general the fulgoroid fauna of south and southwestern China appears to be made up of generic elements of the palaearctic fauna mixed with others from the Burman, Indochinese, and Indonesian faunas. This was noted by Noualhier (1896: 251), and there is little more to be said on this point today. An interesting consideration has been brought to the front by the known great antiquity of the conifer *Metasequoia glyptostroboides.* A new achilid species, assigned below to *Magadha* Distant, is associated, probably rather loosely, with this tree, and, as is general in the family,



undoubtedly spends its nymphal life below bark and inside crevices of rotting branches and tree trunks. The genus *Magadha* was described from northern India and is represented in Ceylon, Assam, and Formosa. It is clearly headquartered in southeastern Asia, and there appears to be no obvious reason why species of this genus, both in the nymphal and adult stages, should not have been associated with *Metasequoia* through an appreciable length of geological time.

Family **CIXIIDAE** Spinola

KEY TO GENERA OF CHINESE CIXIIDAE

(Adapted from Muir)

(1) (2) A subantennal process present on genae .... *Borysthenes* Stål

(2) (1) No subantennal process .... (3)

(3) (4) Sc, R, and M in tegmina arising separately from base, not forming a common stalk .... *Andes* Stål

(4) (3) Sc, R, and M not arising separately from basal cell, two or more united in a common stalk .... (5)

(5) (6) Tegmina in repose steeply tectiform, with apical margins meeting or nearly so, body laterally compressed. Ovipositor with valvulae prominent, more or less ensiform, curved, often accommodated in a longitudinal sulcus .... (7)

(6) (5) Tegmina in repose shallowly tectiform and with apical margins not apposed; abdomen not laterally compressed, sometimes moderately dorsoventrally depressed .... (9)

(7) (8) Vertex distinctly angularly emarginate at apex .... *Kirbyana* Dist.

(8) (7) Vertex truncate at apex, distinctly broader than long .... *Ptoleria* Stål

(9) (10) Tegmina with the first (basal) fork of M closer to the fork of M_3 and M_4 than to the fork of M_1 and M_2 .... *Mnemosyne* Stål

(10) (9) First fork of M in tegmina closer to forking of M_{1+2} than to forking of M_{3+4} .... (11)

(11) (12) Mesonotum with five carinae .... *Oliarus* Stål

(12) (11) Mesonotum with three carinae .... (13)

(13) (14) Carina between vertex and frons obsolete, median frontal carina absent or only present on apical portion .... (15)

(14) (13) Carina between vertex and frons and median frontal carina distinct .... (17)

(15) (16) Tegmina with M 5-branched at apex, Cu_1 3-branched; wings with Cu_1 3-branched; frons as long as discal portion of clypeus or longer .... *Kuvera* Dist.

(16) (15) Tegmina with M 4-branched at apex, Cu_1 2-branched; wings with Cu_1 2-branched; frons distinctly shorter than discal portion of clypeus .... *Betacixius* Mats.

(17) (18) Pronotum laterally carinate between eyes and tegulae .... *Macrocixius* Mats.

(18) (19) Pronotum not laterally carinate, lateral discal carinae following hind margin of eyes .... *Cixius* Latr.

Genus **Andes** Stål

Stål, 1866:166. Logotype, *Andes undulatus* Stål, 1870:747.

Andes uncinatus Fennah, new species.

(Figure 1, A–C.)

Male: length, 3.5 mm.; tegmen, 6.2 mm.

Ochraceous; head, except lateral frontal margins, pronotum immediately

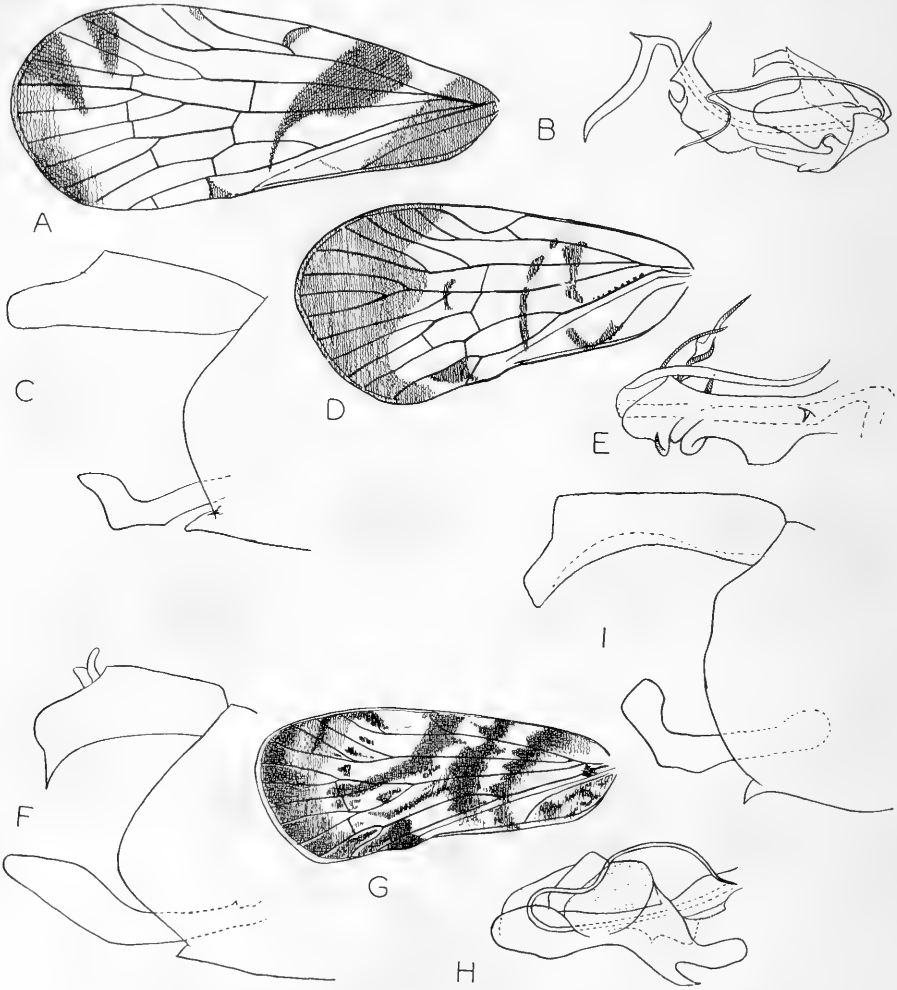


Fig 1. *Andes uncinatus*, new species: A, tegmen; B, aedeagus, left side; C, anal segment, hind margin of pygofer, and right genital style, side view. *Andes othrepte*, new species; D, tegmen; E, aedeagus, right side; F, anal segment, hind margin of pygofer, and right genital style, side view. *Andes noctua*, new species: G, tegmen; H, aedeagus, right side; I, anal segment, hind margin of pygofer, and right genital style, side view.

behind eyes, disc and disc of mesonotum, and abdominal tergites, fuscous; lateral fields of mesonotum brown. Tegmina translucent, basal area to level of union of claval veins, a narrowing curved fascia from middle of costal cell to near apex of clavus, three short stripes more or less in line from distal stigma to apex of clavus, two wedges near apical angle, and a suffusion across apical cells fuscous, a faint band from node to apex of clavus, and a suffusion across membrane yellow.

Anal segment moderately long, bilaterally symmetrical, anal foramen at distal third, apical margin rounded-truncate, latero-apical angles rounded, not produced. Pygofer with lateral margins strongly convex, medioventral process triangular, acute at apex, with a short spine on each side at base. Aedeagus tubular, an irregular denticulate ventral keel, swollen on left side near base and produced in short curved tooth at base, directed basad, distally a foliate lobe on left enwrapping distal left side and apex, flagellum comprising a long slender blade-like spine, slightly denticulate, rising at apex, curved to right then cephalad, completely looped distally, a broad and short lobe on left with a strongly sinuate upper margin, a shortly tapering membranous lobe dorsally. Genital styles of subequal width throughout, rectangulately bent at distal third, obliquely truncate at apex.

One male (the type), 700–900 m. **Kan-Lin-San, Lien-p'ing District, Kwangtung, S. China,** J. L. Gressitt, April 23, 1940. This species differs in genital structure from any of those reviewed by Muir (1925), and in tegminal markings from any known to the writer. In the latter character it perhaps most closely approaches *Andes migratorius* (Dist.). The spines laterad of the medioventral process of the pygofer are exceptional.

Andes othrepte Fennah, new species.

(Figure 1, D–F.)

Male: length, 3.6 mm.; tegmen, 5.0 mm.

Castaneous-brown, lateral carinae of frons and clypeus, an oblique stripe between eye and margin, antennae, pronotum, tegulae, rostrum, and legs testaceous to stramineous. Tegmina subhyaline with greyish powdering; a broad even band from basal cell to middle of clavus and a broad oblique band from costal cell basad of stigma to apex of clavus, dull yellow; a short stripe bounding latter band on its basal margin, and a more or less complete stripe bounding its distal margin, an obliquely L-shaped mark across middle of clavus, a spot just basad of stigma and a slightly larger spot across all Cu_{1b} and apex of clavus fuscous; stigma and membrane pale brown, veins concolorous, minutely granulate with fuscous on corium. Wings translucent, powdered sordid white, with fuscous veins.

Anal segment of male moderately long and rather broad, lateroapical angles acutely produced ventrad, anal foramen slightly distad of middle. Pygofer laterally strongly convex on hind margin, medioventral process subequilaterally triangular. Genital styles elongate, in profile angulately bent at basal third, in posterior view distal portion wider than basal, of subequal width throughout, shallowly rounded at apex. Aedeagus tubular, a triangular flange on ventral surface near base, directed to left; on right ventrally, two-thirds from base, a stout spine directed to left below aedeagus then dorsad; slightly distad of this, ventrally on right, a short stout spine directed to right, then dorsad; at apex a long, rather slender, sinuate process directed cephalad above aedeagus then curved to left; flagellum with two slender unequal spines arising near base, the dorsal slightly curved, the ventral in form of a shallow spiral.

One male (the type), **Hong Kong Island,** Aug., 1933, W. E. Hoffman. This species recalls *A. undulatus* Stål, but differs from the female holotype in tegminal markings, and from the male, as identified by Muir, in the shape of the genitalia.

Andes noctua Fennah, new species.

(Figure 1, G–I.)

MALE: length, 3.2 mm.; tegmen, 4.5 mm. FEMALE: length, 5.1 mm.; tegmen, 6.0 mm.

Dark fuscous: a spot on sides of head above eyes piceous; a series of frequent and fairly even sublinear interruptions on lateral margins of vertex and frons, and a ring round base of antennae pallid stramineous, antennae, lateral fields of pronotum, sometimes interruptedly, rostrum, lower side of thorax and legs stramineous, more or less suffused fuscous.

Tegmina translucent, powdered ash-grey: a narrow irregular stripe from basal third of costal cell to union of claval veins, a zig-zag narrow stripe subparallel to preceding from middle of costal cell to claval suture at apical fifth, a broader oblique band from apex of costal cell to subapical transverse line at M, a band overlying transverse veinlets from M to apex of clavus, apical cells fuscous; a spot at distal edge of stigma and on marginal dilation at apex of clavus fuscous-piceous. Wings translucent, distally suffused fuscous, powdered grey, veins fuscous.

Anal segment elongate, distally shallowly deflexed, apical margin very short, slightly excavate, lateroapical angles scarcely produced, anal foramen in distal quarter. Pygofer with laterodorsal angles obtuse but well-defined, lateral margins convex, medioventral process triangular, flanked on each side at base by a distinct spine-like process. Genital styles short, in profile subrectangulately bent at middle, slightly dilated and rounded-truncate at apex. Aedeagus tubular, a small flange on right near base, directed laterad and minutely denticulate on margin; mesad of this a triangular vertical flange directed ventrad; a broad submembranous trough-like lobe, attached at apex, free at cephalad end, loosely enwrapping aedeagus for most of its length, this lobe truncate at anterior margin on left, on right (ventrolaterally) produced in three short broad lobes, the middle lobe denticulate on margin. A long strongly sinuate spine arising at apex of aedeagus directed cephalad above aedeagus; flagellum short, unornamented.

Two males (one the type) and 8 females, 1,000 m. **Suisapa, Lichuan District,** W. Hupeh, China, July 23, 1948, Gressitt.

In gross structure this species appears to be allied to *A. marmoratus* (Uhl.). The general conformation of the aedeagus is as found in *A. marmoratus,* but the details of its outline are different, while the anal segment is relatively longer basad of the anal foramen and the genital styles differently shaped at the apex. The tegminal markings are less clearly defined than in *A. marmoratus* and in the region of the claval suture distinctly different. The apical venation of R and M described by Muir is not found in the present species.

Andes lachesis Fennah, new species.

(Figure 2, M, N.)

Male: length, 4.0 mm.; tegmen, 5.2 mm. Female: length 4.1 mm.; tegmen, 6.2 mm.

Stramineous to testaceous, disc of frons and clypeus, genae and sides of head above eyes, except for an oblique pallid stripe, vertex, median portion of pronotum and mesonotum, castaneous-fuscous. Tegmina translucent pallid; inner angle of clavus, a broad band from basal cell between Cu_1 and first claval vein to near apex, and two suffused areas on M and Cu_1 fork respectively, yellow; an L-shaped mark near union of claval veins, an arcuate broad fascia from basal third of costa, where it is once interrupted, to clavus near apex, a spot at apex of costal cell and another just distad of stigma, a short stripe across subapical cell M_{1+2} and a spot on margin distad of claval apex, dark fuscous; membrane pale fuscous with two elongate-ovate pallid areas in apical cells. Veins concolorous with fine fuscous granulation. Tegmina sometimes suffused with pale fuscous in all lighter areas. Wings sordid white, veins pale fuscous.

Anal segment of male moderately long, relatively broad, with subparallel sides, apical margin excavate, lateroapical angles asymmetrically produced, anal foramen in distal half. Pygofer with posterior lateral margins broadly convex, medioventral process triangular. Aedeagus with a large vertical triangular keel below, which is continuous above with a loose wide shagreen sleeve which surrounds the aedeagal duct. This loose sleeve bears dorsally a short slender spine directed to right, and below this, a little more cephalad, a small elongate-triangular shagreen lobe. At apex of aedeagus a long stout sinuate spinose process directed cephalad above aedeagus, distally curving abruptly to right and ventrad. Flagellum coarsely shagreen or sub-fimbriate.

Five males (one the type) and two females, **Mokansan, Che-Kiang**

Province, Sept. 19–28, 1927, Mrs. D. E. Wright. A female taken at 1,000 m., Suisapa, Lichuan District, W. Hupeh, China, Aug. 21, 1948, Gressitt, is placed here.

In the denticulate process of the aedeagus this species can be compared with *A. pseudobrunneus* Muir and *A. brunniceps* Muir; it differs from both in the deep ventral carina below the aedeagus, and in the position and shape of the spinose processes, in the shape of the anal segment and genital styles, and in the color pattern of the tegmina.

Genus **Ptoleria** Stål

Stål, 1859a:321. Haplotype, *Ptoleria arcuigera* Stål, 1859a:321.

Ptoleria indica (Distant).

Caneirona indica Distant, 1916:39.

One female, 1,000 m. Suisapa, Lichuan District, W. Hupeh, Aug. 23, 1948, Gressitt, is generally similar to Distant's type but with greater fuscous suffusion over the hind portion of the membrane.

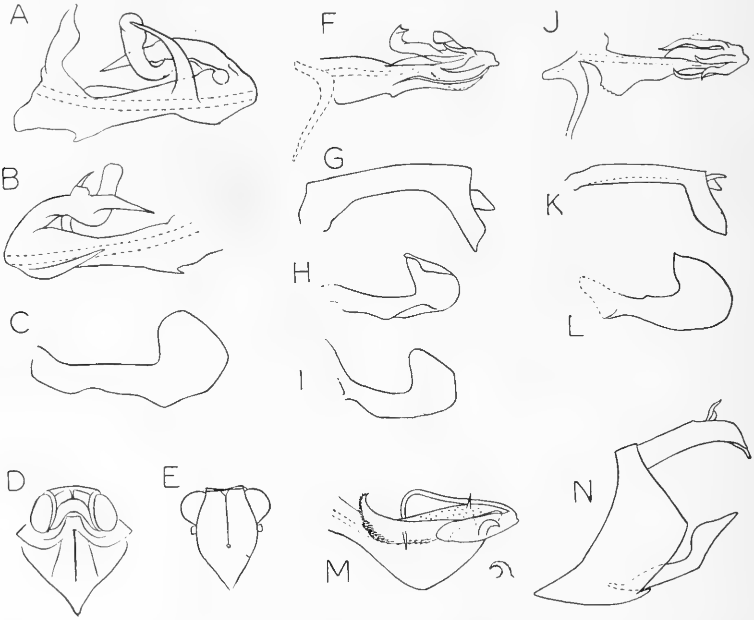


Fig. 2. *Cixius scrupeus*, new species: A, aedeagus, left side; B, aedeagus, right side; C, left genital style; D, head and thorax; E, frons and clypens. *Cixius phonascus*, new species; F, aedeagus, left side; G, anal segment of male, right side; H, right genital style, inner aspect; I, left genital style, outer aspect. *Cixius galeola*, new species: J, aedeagus, left side; K, anal segment of male, left side; L, left genital style. *Andes lachesis*, new species: M, aedeagus, left side (process of left side also shown detached); N, anal segment, pygofer and left genital style.

Genus **Cixius** Latreille

Latreille 1804:310. Logotype, *Cicada nervosa* L. 1758 Syst. Nat. 10:437.

Cixius phonascus Fennah, new species.

(Figure 2, F–I.)

Male: Length, 5.0 mm.; tegmen, 6.1 mm.

Vertex broader across base than long in middle, width of apex more than half of base, both transverse carinae convexly angulate. Dark reddish brown; carinae of pronotum and vertex and legs testaceous. Tegmina translucent, more or less brown with pale areas; basal area usually suffused brown, a diffuse fascia from union of claval veins transversely across to costa, a suffusion in membrane yellowish-brown, apical cells at base and apex fuscous, veins yellow. Wings infuscate distad of transverse veins, veins fuscous.

Tegmina with 1 or 2 Sc veins at apex distad of stigma, 3 R's and 5 M's.

Anal segment long, tubular, deflexed at anal foramen in apical quarter, apical margin deeply rounded. Pygofer short dorsally, long ventrally, with lateral margins obtusely angulately produced, medioventral process short, triangular. Genital styles short, expanding distally, curved through about 110° at middle, angle at apex of dorsal margin slightly produced, acute. Aedeagus tubular, more or less straight, a moderately long spine arising ventrally at apex, shallowly sinuate, directed cephalad below aedeagus, on left near apex a pair of short curved spines, a short upcurved spine on right distally; flagellum more or less tubular, sinuate, directed cephalad.

One male (the type), **Loh Fau Shan, Poh-lo District, Kwangtung, S. China,** April 6–8, 1934; one male and one female, Yaoshan, Lin-hsien, Kwangtung, S. China, May 6–10, 1924.

This species differs from *C. gravelyi* Muir in its larger size, paler body-color, infuscate distal area of the wings, and in the shape of the genital styles; from *C. laticeps* Metc. in almost every detail of coloration. In tegminal markings it is perhaps nearest to *C. velox* Mats., from which it is separated by the proportions of the vertex: from *C. kuyanianus* Mats. it differs in tegminal markings and darker body-color, and, apparently, in the shape of the apical portion of the genital styles.

Cixius galeola Fennah, new species.

(Figure 2, J–L.)

Male: length, 4.9 mm.; tegmen, 6.0 mm.

Vertex only slightly broader across base than long in middle line, width of apex equal to half width between basal angles.

Testaceous; mesonotum castaneous. Tegmina yellowish hyaline; a faint suffusion along costal cell, brown; a bold broad spotted fascia obliquely across membrane from apical cell Cu_1 to apex of Sc; veins yellow. Wings hyaline, a broad suffusion along margin extending inward to cover apical cells, fuscous, veins concolorous.

Tegmina with 2 Sc veins at apex distad of stigma, 3 R's, 5 M's, Sc + R fork basad of Cu_1 fork, which is basad of union of claval veins.

Genitalia similar to preceding, distance between anal foramen and lateral margin shorter than in preceding. Aedeagus tubular, straight, a very short stout curved spine arising ventrally at apex, curved to right, on left side near apex two spines, the ventral spine about half as long as the dorsal, strongly curved anteriorly and cephalad, dorsal spine sinuate, directed anteriorly, on right side near apex a moderately long spine directed cephalad, curved dorsad at its apical third, flagellum as in preceding species. Genital styles as figured.

One male (the type), **Keung-Tin-Heung, Lin-Hsien District, Kwangtung, S. China,** July 13–14, 1934.

Cixius galeola differs from *C. pilosellus* Mats. in that the anterior transverse carinae of the vertex are not acutely angulate, and the clavus is devoid of fuscous markings: from *C. nawae* Mats., apart from differences in tegminal marking, it is separated by the shape of the medio-ventral process of the pygofer, which in *C. nawae* is narrow and oblong: from *C. nitobei* Mats., to which it is perhaps nearest, it differs in the tegminal markings.

Cixius scrupeus Fennah, new species.
(Figure 2, A–E.)

MALE: length, 4.9 mm.; tegmen, 5.6 mm.

Piceous; carinae and margins of head, pronotum and tegulae, femora at apex, yellow or testaceous; post-tarsi and longitudinal stripes on post-tibiae pale fuscous. Tegmina greyish-hyaline, a suffusion at base, one or two in middle of clavus and a spot near its apex brownish fuscous; stigma, except at base, and veins of membrane, fuscous-piceous, veins otherwise stramineous with granules darker. Wings greyish hyaline, veins yellowish, distally fuscous-piceous.

Anal segment elongate-ovate, distal margin shallowly convex, latero-apical angles not produced. Pygofer short dorsally and ventrally, lateral margins broadly produced, medioventral process broadly triangular. Genital styles narrow at base, expanded and curved dorsad distally. Aedeagus tubular, slightly expanding distally, a long stout spine on left side one-third from apex, directed dorsad and curved cephalad at tip, a short spine near apex on right, slightly curved, directed laterad then obliquely dorso-cephalad; flagellum sinuate, distally with a stout spine directed cephalad, apical portion of flagellum in form of an even curved tube.

One male (the type), **Arisan to Hoshe, Tainan-Taichu District, Formosa** July 14, 1948, Gressitt.

In general coloration this species can only be compared with *C. hakonensis*

Mats. It differs in that the frons and vertex are yellowish only at the margins, not entirely, while the legs in *C. hakonensis* are yellow, not mostly piceous as above. In *C. hakonensis* three piceous spots lie close to the costal margin; the medioventral process of the pygofer is narrow and peglike, while the distal margin of the male anal segment is shallowly excavate.

Cixius spp.

One mutilated specimen, 2,300 m. Ali Shan (Arisan), Tainan District, Mar. 10, 1948, L. Gressitt. This species is near *C. kuyanianus* Mats. One female, with a relatively elongate and porrect ovipositor, taken by the above collectors in the same locality on August 20, 1947, is close to *C. arisanus* Mats.

One mutilated specimen and one female, Yaoshan, Lin-hsien District, Kwangtung, S. China, May 6–10, 1934. In this pair the vertex is broader than long and almost as wide at apex as at base.

Genus **Oliarus** Stål

Stål 1862:306. Logotype, *Oliarus walkeri* Stål 1859b:272

Oliarus kurseongensis Dist.

(Figure 4, G–H.)

Distant, 1911, Ann. Mag. Nat. Hist. (8)8:737.

One male, 1,000 m. Suisapa, Lichuan District, W. Hupeh, July 27, 1948, Gressitt.

Oliarus nigronervatus Fennah, new species.

(Figure 3, A–F.)

Male: length, 5.5 mm.; tegmen, 8.0 mm.

Vertex longer than broad (1.26:1), lateroapical aerolets separated by a rectangular median fossette, frons with disc markedly hollowed on each side of median carina, lateral margins obliquely subfoliate, median ocellus visible, though obsolescent. Rostrum slender, apical segment attaining postcoxae, slightly shorter than subapical. Post-tibiae feebly trispinose, apically with five short spines and one long spine, basal metatarsal segment with 7 teeth, second metatarsal with six. Tegmina with Sc + R fork level with Cu_1 fork.

Castaneous-piceous; carinae of head and pronotum, subapical segment of rostrum, femora, and tibiae at apex testaceous; a short bar laterally on frons at apex, extending across genae to antennae, stramineous. Tegmina milky-hyaline, suffused fuscous near apex; veins and margins, except at stigma and apex of clavus, piceous. Wings milky-hyaline, suffused fuscous near distal margin, veins piceous, margins dark fuscous but pale at node.

Anal segment elongate, asymmetrically ovate. Pygofer with laterodorsal angles asymmetrically produced, medioventral process basally parallel-sided, distally acute. Aedeagus narrowly ring-like at base, with three narrow processes, one of them approximately T-shaped, directed caudad as figured. Genital styles long and narrow, more or less straight, slightly swollen before apex.

One male (the type), 1,000 m. **Suisapa, Lichuan District,** W. Hupeh, China, Aug. 19, 1948, Gressitt. This species is distinguished by the shape of the male genitalia. It differs from *O. walkeri* Stål in size and in the presence of a median fossette at the apex of the vertex; in the shape of the vertex from *O. caudatus* (Wlk.), *O. hodgarti* Dist., *O. simlae* Dist., *O. singularis* Muir, *O. geniculatus* Stål, *O. angusticeps* Horv., *O. trifasciatus* Mats. and Matsumura's species *O. horishanus, O. iguchii, O. quadricinctus, O. pachyceps, O. boninensis, O. tappanus, O. speciosus, O. mori, O. hopponis, O. artemisiae,* and *O. kagoshimensis;* in the shape of the male genitalia from all Oriental and Pacific species known to the writer or figured by Muir, and in coloration from *O. stigma* Motsch., *O. tabrobanensis* Mel., *O. fusconebulosus* Dist., *O. binghami* Dist., *O. indicus* Dist., *O. greeni* Dist., *O. annandalei* Dist., *O. prolongulus* Muir, *O. harimaensis* Mats., *O. hachijonis* Mats., *O.*

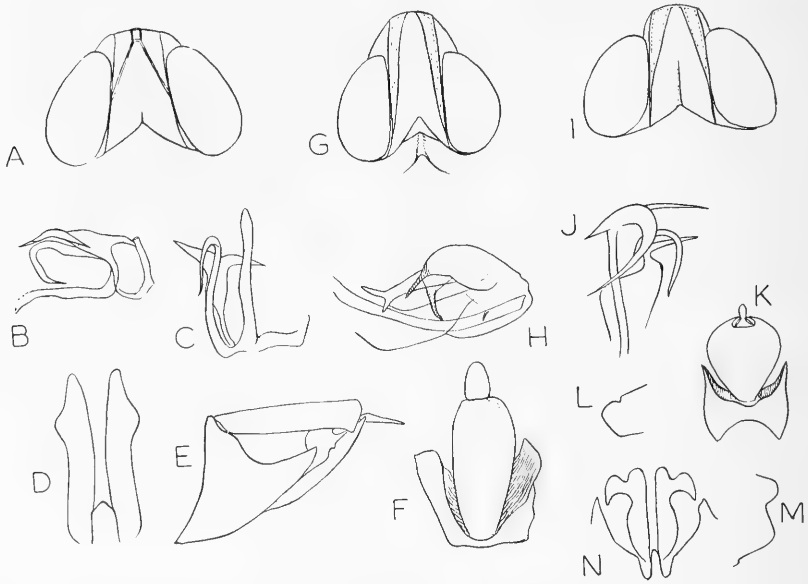


Fig. 3. *Oliarus nigronervatus*, new species: A, vertex; B, aedeagus, right side; C, aedeagus, ventral view; D, medioventral process of pygofer, and genital styles, ventral view; E, male genitalia, left side; F, anal segment and pygofer, dorsal view. *Oliarus cucullatus* Noualh.: G, vertex; H, aedeagus, left side, small ventral spine viewed by transparency. *Oliarus insetosus* Jac.: I, vertex; J, aedeagus, dorsal view; K, anal segment of male; L, sketch of margin of pygofer, right side; M, sketch of margin of pygofer, left side; N, genital styles and medioventral process of pygofer.

ogasawarensis Mats., and *O. apicalis* Uhl. In the shape of the male genital styles it differs from *O. formosanus* Mats., *O. velox* Mats., and *O. oryzae* Mats.

Oliarus cucullatus Noualh.

(Figure 3, G, H.)

Noualhier, 1896:255.

MALE: length, 4.0 mm.; tegmen, 4.8 mm. FEMALE: length 4.5 mm.; tegmen, 5.5 mm.

Vertex narrow, 1.6 times as long in middle line as broad across base, lateroapical areolets long, narrow, extending caudad to one-fifth from base, lateral margins foliate, disc deeply hollowed out, frons and clypeus narrowly lozenge-shaped, disc of frons only shallowly hollowed out on each side of middle, median ocellus not visible, rostrum attaining post-trochanters, with apical segment as long as subapical. Post-tibiae laterally bispinose, apically six-spined. Basal metatarsal segment seven-toothed, second segment five-toothed. Tegmina with Sc + R fork level with Cu_1 fork.

Castaneous-fuscous; carinae broadly, tegulae, femora and tibiae at apex, post-tarsi, and hind margins of abdominal ventrites stramineous; two spots on side of head above eyes greyish-white. Tegmina of male translucent, subopaque, powdered sordid white, veins yellow except at apex, obscurely granulate, cross-veins and apical veins fuscous; tegmina of female either as in male or yellowish-hyaline at base of clavus, otherwise fuscous-castaneous, except for yellow proximal and ventral margins of stigma, veins concolorous or fuscous. Wings wholly greyish-white with brown veins (male) or distally infuscate with fuscous veins (female).

Anal segment of male asymmetrical, right margin excavate. Pygofer with lateral margins asymmetrically produced into a broadly rounded lobe on left side, and a turbinate subacute lobe on right, medioventral process short, acute. Aedeagus tubular, a broad triangular lobe, terminating in a spine on right near apex directed ventrad, flagellum terminating in a pair of short spines directed slightly to right, on left two spines. Genital styles in ventral view parallel-sided, at apex narrowly and acutely produced laterad, and feebly roundly produced mesad.

Anal segment of female moderately short, lateral margins shallowly rounded, apical margin truncate. Posterior margin of seventh sternite very shallowly excavate in middle. Ovipositor with first valvulae much reduced, shortly triangular, third valvulae about as long as anal segment, elongate-triangular, flattened and blade-like.

One male, Hangchow, China (May 22, 1923) E. C. Van Dyke, 1 female, Sui-Kwan San, Tin-tong, Loh-chan District, Kwangtung, S. China, Aug. 1947; 13 males, 14 "pale" females and 15 "dark" females, 1,000 m. Suisapa, Lichuan District, W. Hupeh, China, July 19–25, 1948. One mutilated male, Pan-yu District, Honam Island, Canton, S. China, May 1–15, 1934, W. E. Hoffman, and a mutilated specimen from Honam Island, May 16, 1933, W. E. Hoffman, are assigned to this species. This species recalls *O. simlae* Dist. but differs from the type in the shape of the vertex: it is highly probable that *Mnemosyne* (?) *sinica* Jac. is conspecific, but the evidence is too weak to justify the suppression of Jacobi's trivial name.

Oliarus insetosus Jac.
(Figure 3, I–N.)
Jacobi, 1944:13.

MALE: length, 3.6 mm.; tegmen, 4.0 mm. FEMALE: length, 3.2 mm.; tegmen, 4.3 mm.

Vertex longer in middle line than broad (1.5:1), lateroapical areolets extending backward to one-third from base, contiguous at apex. Frons with disc very shallowly tectiform, scarcely concave between carinae; median carina forked at base, rostrum with apical segment slightly shorter than subapical, attaining postcoxae. Tegmina with Sc + R fork much distad of Cu_1 fork. Post-tibiae feebly trispinose laterally, with six spines at apex, basal metatarsal segment with 7 teeth at apex, second metatarsal segment with five teeth.

Piceous, carinae and margins of head and pronotum, femora at apex, post-tibiae and all tarsi, margins of abdominal ventrites testaceous or ochraceous. Tegmina subhyaline, powdered greyish-white, stigma, distal transverse veins, and apical veinlets piceous, veins otherwise stramineous. Wings greyish white, distal margin and apical veins narrowly fuscous, veins otherwise pale yellowish-brown.

Anal segment of male obcordate-ovate, apical margin deflexed and shallowly excavate. Pygofer with lateral margins slightly asymmetrical, that on left in profile with laterodorsal angle roundly produced, margin subrectangulate below this: margin of right side very slightly notched near lateroapical angle, apical margin oblique, medioventral process moderately long, narrow, acute, in side view shortly bladelike, striate. Aedeagus dorsoventrally compressed, a short spine below, near middle directed to right, two longer curved spines on left near apex directed to left, at apex a slightly shorter curved spine directed to left, subparallel to preceding, a broad falcate lobe arising on left at apex, directed dorsad and cephalad, opposite this on right a membranous flagellum, slightly shorter. Genital styles as figured.

Pregenital sternite of female with hind margin only very slightly produced, and very shallowly excavate medially.

One male, P'an Yu District, Honam Island, Canton, S. China, April 20, 1934, W. E. Hoffman; one female, Un-long, New Territories, Hong-Kong, Sept. 19, 1940, J. L. Gressitt; four males and one female, 800–1,000 ft. trail between Lau-Tau-Di and Chang-Tau-Ching, Szechwan, China; one male, Sang-Hou-Ken, Hupeh-Sze Border, China, July 19, 1948, Gressitt. This species differs from *O. walkeri* Stål, which it closely resembles, in size, in the distinctly longer lateroapical facets of the vertex, and in the shape of the male genitalia.

Oliarus petasatus Noualh.
Noualhier, 1896:255.

Length about 4.5 mm.; tegmen, 6.0 mm.

Median ocellus present. Rostrum with apical segment slightly exceeding sub-apical, attaining post-coxae. Post-tibiae 3–5 spined (base and supernumerary feeble), apically 6-toothed, basal metatarsal segment 7-toothed, second metatarsal 5-toothed.

Venation as in *O. cucullatus;* Sc + R forked slightly distad of Cu_1, one apical Sc vein beyond stigma, 3 Rs, 5 Ms. Castaneous-piceous; carinae and margins of head, and tegulae, brownish-yellow, tibiae and tarsi paler. Tegmina hyaline, stigma yellowish-brown, veins stramineous; cross-veins and forks of clavus, Cu_1, and a minute spot in middle of vein M on corium infuscate.

One mutilated specimen, 1,900 m. Kunming, Yunnan-fu, Yunnan, S. W. China (July 4, 1940), Gressitt.

This species superficially appears to be closely related to *O. cucullatus,* but it stands apart in the shape of the vertex and the presence of a functional median frontal ocellus.

Genus **Nesopompe** Kirkaldy

Kirkaldy, 1907:107. Orthotype, *Oliarus felis* Kirkaldy, 1906:399

Nesopompe tsoui Muir.
Figure 4, A–F.)
Oliarus tsoui Muir, 1925:365.

Two males, 1,000 m. Suisapa, Lichuan District, W. Hupeh, China, June 23, 1948, (Gressitt); 1 male, Mimasaka, Japan, July, 1912, (J. C. Thompson).

Genus **Betacixius** Matsumura

Matsumura, 1914:412. Orthotype, *Betacixius ocellatus* Mats. 1914:412

KEY TO SPECIES OF BETACIXIUS

(1) (2) Tegmina with a large, ocellate black spot apically .... (3)
(2) (1) Tegmina without such a spot distally .... (5)
(3) (4) An oblique brown band extending from clavus part way across middle of corium .... *B. tonkinensis* Mats.
(4) (3) Corium of tegmina without such a band .... *B. ocellatus* Mats.
(5) (6) Tegmina with a tapering oblique dark band extending from stigma along nodal line of cross veins to Cu .... (7)

(6) (5) Tegmina without such a band .... (15)

(7) (8) Tegmina with apical cells of M and Cu strongly infuscate .... *B. transversus* Jac.

(8) (7) Tegmina with apical cells not infuscate .... (9)

(9) (10) Tegmina with apical margin black or obviously very dark .... (11)

(10) (9) Tegmina with apical margin fuscous or not especially darkened .... (13)

(11) (12) Frons with a pallid spot at middle of lateral margins, clypeus dark, mesonotum testaceous .... *B. kumejimae* Mats.

(12) (11) Frons without such spots; mesonotum, except scutellum, castaneous-piceous .... *B. euterpe*, new species

(13) (14) Tegmina with an oblique dark band extending from clavus into middle of corium, little distad of level of union of claval veins .... *B. pallidior* Jac.

(14) (13) Tegmina with a spot near sutural margin of clavus near union of claval veins, no oblique dark band at this level extending into corium .... *B. obliquus* Mats.

(15) (16) Tegmina greyish hyaline, only infuscate at stigma .... male *B. nigromarginalis*, new species

(16) (15) Tegmina with a dark spot or line in clavus .... (17)

(17) (18) Tegmina with apical margin black or very dark .... (19)

(18) (17) Tegmina with apical margin not especially dark .... (25)

(19) (20) A V-shaped dark mark in stigma, an oblique band from middle of clavus extending into corium .... *B. nigromarginalis*, new species

(20) (19) No such oblique fascia from clavus into disc of corium .... (21)

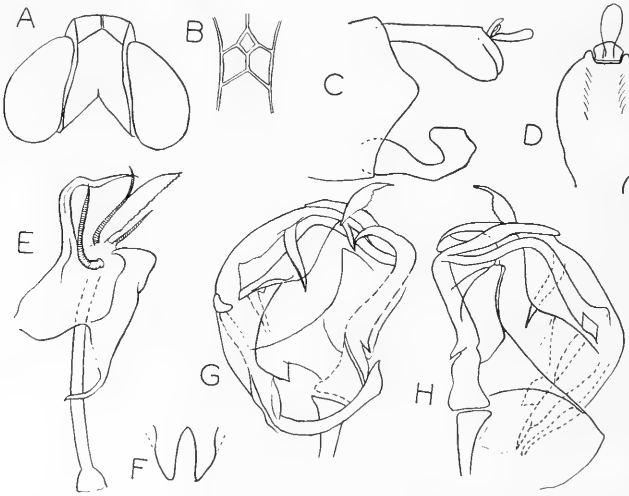


Fig. 4. *Nesopompe tsoui Muir*: A, vertex; B, fossette of vertex; C, anal segment, hand margin of pygofer, and genital style, side view; D, anal segment of male, dorsal view; E, aedeagus; F, medioventral process of pygofer. *Oliarus kurseongenesis* Dist.: G, aedeagus, left side; H, aedeagus, right side.

(21) (22) Costa black, a curved black line in stigma, a spot in clavus .... *B. rinkihoni* Mats.

(22) (21) Costa not especially dark, posterior margin of clavus dark .... (23)

(23) (24) Clypeus distally black, pronotum laterally pallid, tegulae sordid yellow, their posterior edge dark .... *B. clypealis* Mats.

(24) (23) Clypeus distally brown, pronotum laterally brown, pallid only at margin, tegulae light brown .... *B. brunneus* Mats.

(25) (26) Stigma and first apical cell of tegmen piceous .... *B. robustus* Jac.

(26) (25) Stigma dark, a dark suffusion over all apical cells and across base of tegmina .... *B. nelides*, new species

Betacixius nigromarginalis Fennah, new species.

Male: length, 3.2 mm.; tegmen, 4.2 mm. Female: length, 3.4 mm.; tegmen, 5.0 mm.

Reddish-brown; frons lateroapically, lateral margins of pronotum (occasionally whole pronotum) and trochanters, stramineous-yellow; pronotal disc, mesonotum and abdominal tergites castaneous to piceous. Tegmina of female hyaline with greyish bloom, stigma with narrowly V-shaped mark fuliginous, Sc in stigma and vein round apical margin black; a narrow transverse fascia across clavus at apical third, extending into corium to cell M, a tinge at base of clavus reddish-brown; basal margin of clavus yellowish. Tegmina of male usually dark only at stigma, otherwise hyaline with stramineous veins. Wings hyaline with stramineous veins.

Anal segment of male moderately long, telson slightly basad of middle, apical margin transverse-concave, apical angles acuminately produced. Pygofer with lateral margins strongly convex, medioventral process subtriangular, rounded at apex. Genital styles S-shaped, apposed ventral margins enclosing a broadly ovate space, distal portion of each style falcate. Aedeagus with a circularly curved spine on left near apex and a short ledge in a similar position on right; flagellum lying above left margin, sides parallel for most of length, distally a short curved spine directed cephalad, and below this a subquadrate plate with a stout spine directed ventrad.

Described from 8 males (one the type) and 20 females, **Suisapa, Lichuan District, W. Hupeh, China,** on ridge about 1,200 to 1,500 m. (Gressitt, July 19–25, 1948). This species is distinguished by the shape of the male genitalia and by coloration.

Betacixius nelides nelides Fennah, new species and new subspecies.

Male: length, 3.5 mm.; tegmen, 4.2 mm. Female: length, 3.5 mm.; tegmen, 4.8 mm.

Fuscous; carinae and median area of frontal disc reddish-brown, hind margin of pronotum, hind tibiae, and tarsi stramineous; lateral fields of pronotum, fore and middle legs, and post-femora yellow with pale fuscous suffusion; clypeus, mesonotum, pro- and mesocoxae and mesopleura, and abdomen castaneous-piceous. Tegmina hyaline with greyish bloom, a faint suffusion at base, stigma, a small spot overlying union of claval veins, and sometimes a faint suffusion over membrane, fuscous, veins testaceous. Wings hyaline, with greyish bloom, veins fuscous.

Anal segment moderately short, asymmetrical, subovate, acutely rounded at apex, right margin produced and lateroapically deflexed in profile, anal style situated at middle; pygofer with lateral margins symmetrically convex, medioventral process broader across base than long, distally rounded. Genital styles narrow and curved basally, apically subreniform in outline, axis of apical area at right angle to basal stalk. Aedeagus with a large curved spine ventrally near apex, arising on left, curved below aedeagus and directed to right, a stout spine near apex, closely adpressed to left side and directed cephalad, flagellum with a long curved spine at base directed cephalad but decurved at abruptly-tapering apex, and a more slender curved spine directed cephalad.

Three males (one the type) and 4 females, **Tung-lu, Che-Kiang Province, China,** (Mrs. D. E. Wright, May 22, 1926). Two females from Mokansan in the same province (Mrs. D. E. Wright, Aug. 24, 1927) are doubtfully placed here.

This species is distinguished by the combination of characters given in the synopsis and by the form of the male genitalia.

Betacixius nelides atrior Fennah, new subspecies.

MALE: length, 4.2 mm.; tegmen, 5.0 mm. FEMALE: length, 3.7 mm.; tegmen, 5.0 mm.

Fuscous-piceous; basal half of frons reddish brown; rostrum, except at apex, pro- and mesochanters, post-tibiae, and tarsi stramineous.

One male and 1 female, **Hangchow, China,** (E. C. Van Dyke, May 19, 1923). This geographical subspecies is distinguished by its darker coloration.

Betacixius euterpe Fennah, new species.

MALE: length, 3.6 mm.; tegmen, 4.8 mm.

Testaceous; pronotal disc pale yellow; mesonotum, except scutellum and middle portion of abdominal tergites, castaneous-piceous. Tegmina hyaline with greyish bloom, a faint suffusion at base, a fascia from sutural margin at middle of clavus across Sc + R, another from stigma along nodal line to Cu, a suffusion just distad of apex of clavus, and apical margin, fuscous-piceous.

Anal segment of male bilaterally symmetrical, apical margin transverse, lateroapical angles acuminate. Pygofer with lateral margins convex, medioventral process triangular, acute at apex. Genital styles S-shaped, width of distal portion of stalk equal to that of vertical apical portion. Aedeagus with a stout spine arising laterally on left near apex, directed cephalad, slightly decurved at tip, a curved spine directed to right lying below flagellum in its basal half, a more slender curved spine, directed ventrally, arising on right side of flagellum near apex.

One male (the type), **Hau-leng, Tin-tong, Loh-chan District, Kwangtung Province, S. China,** (Aug. 1, 1947).

This species is distinguished by the combination of characters given in the synopsis and by the form of the male genitalia.

A female from Yaoshan, Liu-hsien District, Kwangtung (May 10, 1934), (length 3.1 mm.; tegmen 4.3 mm.), provisionally placed here, but probably representing another species, differs from the male of *B. euterpe* in having the lower part of the genae and lateroapical areas of the frons pale yellow, apical part of clypeus, procoxae, and mesopleura and basal part of mesocoxae castaneous-piceous, and legs fuscous; tegmina with a spot in clavus slightly distad of union of veins, a fascia from stigma along nodal line to Cu, all apical cells in M and Cu fuscous, margin between stigma and suffused apical area, testaceous-brown.

Genus **Macrocixius** Matsumura

Matsumura, 1914:393. Orthotype, *Macrocixius giganteus* Mats.

Macrocixius giganteus Mats.
Matsumura, 1914:394.

One female, 1,000 m., Musha (Wuse) to Bandai, Taichung District, Formosa, Aug. 24, 1947, Gressitt.

Genus **Borysthenes** Stål

Stål, 1866:165. Logotype, *Cixius finitus* Stål, 1866:392.

Borysthenes maculatus (Mats.).
Barma maculata Matsumura 1914:430.

One male, Chizuka, Okinawa, July–Sept., 1945, Bohart and Harnage.

Borysthenes acuminatus Fennah, new species.
(Figure 5, A–E.)

Male: length, 4.1 mm.; tegmen, 6.0 mm.

Testaceous; middle portion of frons and clypeus except at apex, all coxae and hind femora and tibiae faintly suffused fuscous; mesonotum and posttarsi castaneous; clypeus at apex, apical segment of rostrum, fore and middle legs distad of trochanters and abdominal ventrites dark fuscous to fuscous-piceous.

Tegmina subtranslucent, ivory white on most of corium, greyish white in costal cell and membrane, three broad fasciae, one at base, another arcuately across middle, and the third over most of membrane as figured, chocolate brown. Wings pallid with cross veins and a broad submarginal fascia, sepia brown.

Anal segment of male moderately short and broad, lateroapical angles not symmetrical. Pygofer with lateral margins slightly asymmetrical, medioventral process distally semicircularly rounded. Genital styles with inner and outer margins (in posterior view) subparallel, apical margin straight and strongly oblique, occasionally slightly reflected.

Described from 4 males (one the type), **1,000 m. Lichuan District, W. Hupeh, China,** July 23–25, 1948, Gressitt.

This species is distinguished by tegminal pattern and by the shape of the male genitalia.

Borysthenes deflexus Fennah, new species.

(Figure 5, I, J.)

MALE: length, 4.1 mm.; tegmen, 6.0 mm. FEMALE: length, 5.0 mm.; tegmen, 7.0 mm.

Ochraceous-testaceous; mesonotal disc and abdomen slightly infuscate. Tegmina translucent, powdered greyish, an arcuate irregular band from middle of clavus to basal third of costal cell, a more deeply convex band

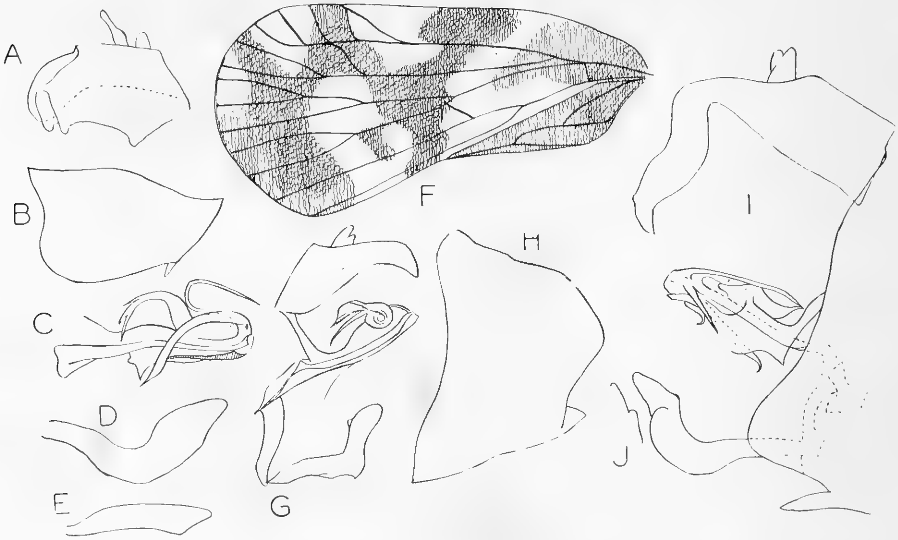


Fig. 5. *Borysthenes acuminatus*, new species: A, anal segment of male, right side; B, pygofer, right side (basal margin uppermost); C, aedeagus, left side; D, genital style, left side; E, ditto, ventral view. *Borysthenes emarginatus*, new species: F, tegmen; G, anal segment, aedeagus, and left genital style; H, pygofer, left side. *Borysthenes deflexus*, new species: I, anal segment, hind margin of pygofer, aedeagus, and right genital style, side view; J, distal outer margin of genital style, posterior view.

from middle of costal cell to distad of apex of clavus, an interrupted band from node to sutural angle, an ovate spot in apical cells near apical angle, fuscous. Wings translucent with a suffusion on costa near base and two transverse bands distally.

Anal segment of male symmetrical, acuminate at apex, in profile deflexed through 90° distad of anal foramen. Pygofer with lateral margins subrectangulately convex, medioventral process elongate-triangular. Aedeagus tubular, a short straight spine on right near apex directed ventro-cephalad, on left side near apex a short spine curved ventrad and a long porrect spine directed ventro-cephalad, and decurved at tip, a long slender spine arising dorsally at apex directed cephalad, flagellum membranous, apex subspinose and curved dorsad.

Genital styles in profile curved dorsad distally, upper and lower margins subparallel, a rounded ledge on outer face one-fifth from apex, apex acutely rounded, upper distal margin truncate.

One male (the type), **Tso-kok-wan, Lungtau Shan,** altitude 250–350 m., **Kwangtung,** June 5, 1947, Gressitt; 1 female, Keung Tin Heung, Linhsien, Kwangtung, S. China, July 16–17, 1934.

This species is distinguished by the tegminal pattern and by the shape of the male genitalia.

Borysthenes emarginatus Fennah, new species.

(Figure 5, F–H.)

Male: length, 4.1 mm.; tegmen, 5.6 mm.

Testaceous; middle portion of frons, clypeus, all coxae, postfemora, and tibiae very slightly darker; pronotum around disc, and mesonotum, infuscate, rostrum at tip piceous.

Tegmina subtranslucent, sordid pallid yellow, a >-shaped cloud near base reddish-brown; a broad fascia from costal cell near apex to sutural margin distad of apex of clavus, a broader transverse band across middle of membrane, apical cells of R and M_1 fuscous, veins concolorous. Wings translucent powdered sordid white, veins fuscous.

Anal segment of male in profile slightly deflexed distad of middle, apical margin deeply excavate to level of anal foramen. Pygofer with lateral margins subangulately convex. Aedeagus tubular, a long slightly curved spine on right at apex, directed cephalad, flagellum twisted through 360°, minutely denticulate on margin distally. Genital styles in profile strongly angulately bent just distad of middle, an eminence distally on inner margin.

One male, **White Cloud Mountain, P'an Yu District, Canton, S. China,** May 5, 1934. This species is distinguished by coloration and by the shape of the male genitalia.

Family **DELPHACIDAE** Leach

KEY TO GENERA OF CHINESE DELPHACIDAE

(1) (2) Post-tibial spur awl-shaped, circular in cross section; mesonotum with five carinae .... *Ugyops* Guer.

(2) (1) Spur not as above; mesonotum tricarinate .... (3)

(3) (4) Spur thick, flattened or concave on inner face, margin without teeth.... (5)

(4) (3) Spur thin, usually deeply concave on inner face, margin with or without teeth .... (15)

(5) (6) Lateral carinae of frons and vertex only moderately developed........ (7)

(6) (5) Lateral carinae of frons and vertex deeply foliate........ *Purohita* Dist.

(7) (8) Vertex subtriangular with sides slightly convex, sometimes elongate .... *Tropidocephala* Stål

(8) (9) Vertex quadrate .... (9)

(9) (10) First segment of antennae not more than half as long as second........ (11)

(10) (9) First segment of antennae at least two-thirds length of second........ (13)

(11) (12) Mesonotum shorter than head (in dorsal view) and pronotum together .... *Eurysa* Fieb.

(12) (11) Mesonotum longer than vertex and pronotum together.... *Pundaluoya* Kirk.

(13) (14) Frons at least twice as long as broad, clypeus medially carinate .... *Arcofacies* Muir

(14) (13) Frons not nearly twice as long as broad, clypeus devoid of median carina .... *Arcofaciella*, new genus

(15) (16) Basal segment of antennae subtriangular or sagittate, widening distad .... (17)

(16) (15) Antennae with basal segment not as above, cylindrical or slightly compressed .... (21)

(17) (18) Antennae with basal segment sagittate; clypeus in profile subrectangulate at middle; median carina of frons forked at extreme base .... *Belocera* Muir

(18) (17) Antennae with basal segment triangular but not sagittate; clypeus in profile not angulate at middle........ (19)

(19) (20) Frons with paired submedian carinae........ *Pseudaraeopus* Kirk.

(20) (19) Median carina of frons forked near level of lower margin of eyes .... *Perkinsiella* Kirk.

(21) (22) Basal segment of post-tarsus with one or more spines on side .... *Nilaparvata* Dist.

(22) (21) Basal segment of post-tarsus devoid of spines on side........ (23)

(23) (24) Basal segment of antennae short, as long as broad or a little longer.... (25)

(24) (23) Basal segment of antennae not very short, longer than broad........ (35)

(25) (26) Vertex distinctly longer than broad........ (27)

(26) (25) Vertex at most only slightly longer than broad, often equal to width or even shorter .... (31)

(27) (28) Oblique carinae of vertex meeting at apex, or only slightly before it.... (29)

(28) (27) Oblique carinae of vertex meeting much before apex and continued distad as a single median carina .... *Saccharosydne* Kirk.

(29) (30) Second antennal segment not more than twice length of basal segment, median fossette on vertex subtriangulately elongate............ *Sardia* Mel.

(30) (29) Second antennal segment three times length of basal segment, medio-apical fossette about as long as broad, polygonal-rounded........................ .... *Stenocranus* Fieb.

(31) (32) Median carina of frons forked at about one-third from base, or distad .... *Dicranotropis* Fieb.

(32) (31) Median carina of frons simple or forked only at extreme base................ (33)

(33) (34) Vertex at base more than twice as broad as an eye in the same line............ .... *Eoeurysa* Muir

(34) (35) Vertex not twice as broad as an eye.. *Delphacodes* Fieb.

(35) (36) Clypeus fully three-quarters as long as frons; frons three times as long as broad.. *Sogata* Dist.

(36) (35) Clypeus scarcely two-thirds as long as frons; frons two and a half times as long as broad.. (37)

(37) (38) Median carina of frons forked at extreme base of frons; basal segment of antennae more than twice as long as broad at apex................................ .... *Ukanodes*, new genus

(38) (37) Median carina of frons forked near level of middle of eyes; basal segment of antennae relatively shorter.. .... *Chloriona* Fieb. subg. *Sogatella*, new subgenus

Subfamily **ASIRACINAE** Fieber

Genus **Ugyops** Guérin-Méneville

Guérin-Méneville, 1834:477.

Haplotype, *Ugyops percheronii* Guérin-Méneville, 1834:477.

Ugyops vittatus (Mats.).

(Figure 6, A, C, F, G, J.)

Bidis vittata Matsumura, 1906:31, pl. 1, fig. 5.

Frons longer than broad (3:1); basal segment of antennae slightly less than two-thirds of length of second; genae not inflated below level of antennae. Aedeagus, viewed from left, with basal third of flagellum sinuate, the upper and lower margins subparallel.

One male, Chizuka, Okinawa, July–Sept., 1945, Bohart and Harnage. This species differs from *U. kinbergi* Stål from Ponape in the relatively shorter frons and smaller size.

Ugyops zoe Fennah, new species.

(Figure 6, B, D, E, H, I.)

MALE: length, 6.3 mm.; tegmen, 8.5 mm.

Frons longer than broad (3.3: 1), submedian carinae uniting one-third from apex, genae distinctly inflated below level of antennae; basal segment of antennae two-thirds length of apical segment; vertex with posterior margin almost level with middle of eyes. Pronotal disc relatively broad, its lateral carinae distinctly convex.

Testaceous; common carinal eminence at base of frons and apex of vertex, intercarinal areas of anterior half of vertex, a weak intercarinal stripe on each side of frons at base, a small suffusion on sides of head above eye, carinae of vertex finely, median carina of pronotum, posterior margin and a faint cloud behind eyes, and mesonotal carinae, castaneous; second segment of antennae, protibiae, and tarsi fuscous. Tegmina sordid hyaline, lightly waxed grey, veins castaneous interrupted testaceous, apical portion of cells at distal margin infuscate; a broad infuscate Y-shaped band extending from apical margin between R and M_2 to cell M_3, where one limb passes to the margin at Cu_{1b} and the other to the nodal line between Cu and M.

Anal segment of male moderately short, bilaterally symmetrical. Pygofer with lateral margins convex caudad, rather angulately excavate below. Aedeagus, viewed from left, with basal third of flagellum markedly dilated, with ventral margin more convex than dorsal.

Holotype male, **Tai-pin-t'suen, Lam-ka-heung, Lai-mo-ling, Kiung Shan District, Hainan Island,** July 20–21, 1935; one male, Tsai-Chau (Tinhosa) Island, June 2, 1932, Hoffman; and one mutilated specimen, Tung-Chung, Lan-Tau Island (near Hong-Kong), Aug. 16–19, 1934.

Ugyops zoe broadly resembles *U. vittatus* (Mats.). The genae are inflated below the eyes (not in *U. vittatus*), the lateral carinae of the pronotal disc

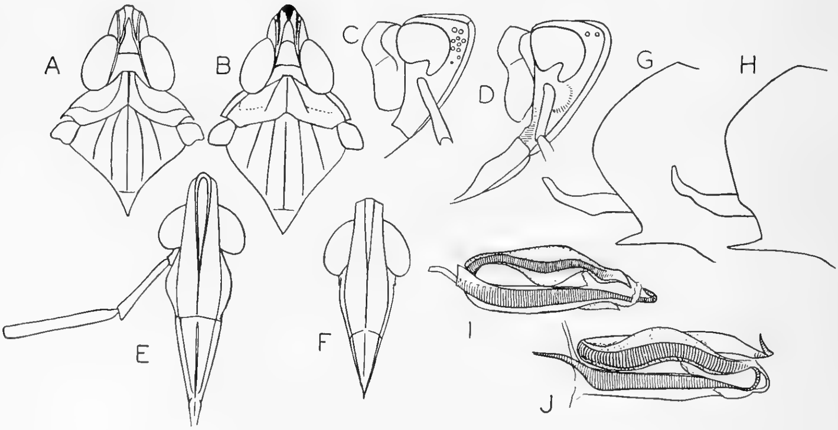


Fig. 6. *Ugyops vittatus* Mats.: A, head and thorax, dorsal view; C, head in profile; F, frons and clypeus; G, pygofer and right genital style, side view; J, aedeagus, left side. *Ugyops zoe*, new species: B, head and thorax; D, head in profile; E, frons and clypeus; H, pygofer and right genital style; I, aedeagus, left side.

are convex (concave in *U. vittatus*), and the tegmina are longer and differently marked. This species has a much shorter frons than *U. kinbergi* Stål, from which, as from *U. vittatus*, it differs in the shape of the male genitalia and in size. It differs from *U. pictifrons* Stål, *U. impictus* Stål, and *U. percheronii* Guér. in coloration and marking (the genitalia of the last three were not available for comparison).

Subfamily **DELPHACINAE** Jensen-Haarup

Tribe **Tropidocephalini** Muir

Genus **Arcofacies** Muir

Muir, 1915:319. Orthotype, *Arcofacies fullawayi* Muir

Arcofacies fullawayi Muir.
Muir, 1915:320.

One female, 300 m. Pe-poi, N. of Chung-King, Sze-chuan, W. China, July 27, 1940, J. L. Gressitt; two females, Hong-Kong, China, Oct., 1895, Koebele.

Genus **Eoeurysa** Muir

Muir, 1913:249. Orthotype, *Eoeurysa flavocapitata* Muir

Eoeurysa flavocapitata Muir.
Muir, 1913:249.

Four males and two females on sugar cane, Pan-yu District, Honam Island, Canton, S. China, May 23, July 26–31, 1935; Jan. 10, 1937, W. E. Hoffman.

Genus **Tropidocephala** Stål

Stål, 1853:266. Haplotype, *Tropidocephala flaviceps* Stål, 1855:93

Tropidocephala brunnipennis Sign.
Signoret, 1860:185.

One male, Sam-ah-Kong, Yai-hsien District, Hainan Island, S. China, Feb. 1, 1935; one female, Honam Island, Canton, China, April 7, 1933; one female, Loh Fau Shan, Poh Lo District, Kwangtung, S. China, April 6–8, 1934.

Tropidocephala festiva (Distant).
Smara festiva Distant, 1906:478.

One female, Cheung-nga-San, Tin-tong, Loh-Chang District, Kwangtung, Aug. 16, 1947, Tsang, one female, Yen-ping, Nan-ping District, Fukien, June and July, 1933; one female, Yaoshan, Lin-hsien District, Kwangtung, April 27–28, 1934; one female, Hau-leng, Tin-tong, Loh-chang District, Aug. 1, 1947.

Tropidocephala speciosa Bierm.
Orchesma speciosa Bierman, 1908:29.

One female, Yaoshan, Lin Hsien District, Kwangtung, S. China, April 24–26, 1934.

Tropidocephala breviceps Mats.
Matsumura, 1907:58.

One female, Hoi-How, Kiung-Shan District, Hainan, S. China, 1932, W. E. Hoffman.

Tropidocephala signata Dist.
Distant, 1912:192.

One female, Rivière de Hue, Anam, March 16, 1927, Mrs. D. E. Wright.

Genus **Pundaluoya** Kirkaldy

Kirkaldy, 1902:52. Orthotype, *Delphax ernesti* Kirby, 1891:140

Pundaluoya sp.

One female, testaceous, with yellowish-hyaline tegmina, slightly infumed on membrane, 1,000 m. Suisapa, Lichuan District, W. Hupeh, China, July 24, 1948, Gressitt.

Arcofaciella Fennah, new genus

Head with eyes as wide as pronotum.

Vertex more than three times as broad as long in middle, anterior and posterior margins transverse, lateral margins slightly convex, strongly converging anteriorly, median carina simple, straight, frons inclined anteriorly in profile, slightly longer than broad, broadest at level of lower margin of eyes, lateral margins convex, median carina simple, shortly forked at base, area within fork apparently depressed; clypeus in profile more or less at right angle to base of frons, lateral carinae straight, median carina obsolete. Rostrum with subapical segment exceeding apical, apex reaching mesotrochanters. Antennae short, stout, second segment markedly longer than first, but both together not exceeding length of eye. Pronotum more than twice as long as vertex, anteriorly shallowly convex, posteriorly shallowly excavate, median carina distinct, lateral carinae developed only in anterior portion in line with lateral margins of vertex; mesonotum strongly convex, almost gibbous, tricarinate, mesoscutellum horizontal. Legs relatively short and stout, profemora not longer than procoxae, post-tibiae with a small spine laterally at base, another about a third from apex, five teeth at apex, spur short, convex, devoid of teeth except for a minute tooth at apex, basal metatarsal segment with about 8 small even teeth. Tegmina long, corium enfolding abdomen at region of node, costal margin sinuate, concave distad of node, apical margin shallowly undulate, forks of Sc–R and Cu_1 distad of union of claval veins, eight cells at apex, excluding stigmal cell.

Arcofaciella verrucosa Fennah, new species.
(Figure 7, A–F.)

Holotype, Female: length, 2.5 mm.; tegmen, 4.3 mm.

Greenish-stramineous; two spots on vertex and impression in fork of median carina of frons orange. Tegmina translucent-ochraceous, a small round callus near Sc–R fork and another near Cu_1 fork piceous, a faint transverse stripe across middle of clavus, and apical veins at margin, brown. Wings yellowish hyaline, veins concolorous.

Third abdominal segment of male produced laterally in a narrowly conical process which is bent caudad. Anal segment very short, ring-like. Pygofer moderately long, longest at middle, laterodorsal angles not produced, posterior lateral margins broadly sinuate, ventral margin convex and oblique in profile, medioventral process absent; diaphragm sclerotised only laterally, devoid of armature in middle and not developed as a sclerotised bridge above base of genital styles. Aedeagus comprising a laterally-compressed plate, narrowing distad and strongly deflexed, recurved caudad at blunt apex; on right side of this a long slender spinose process, evenly curved ventrad and mesad distally, crossing the former process at apex. Genital styles rather long, vertical, very slightly curved, of subequal width from base to near apex, then abruptly bent caudomesad and slightly narrowed; apical margin shallowly concave, distal angles prominent, the lower especially so.

Holotype female, **Hong Kong, China,** Koebele, October, 1895, deposited in the California Academy of Sciences. Allotype male, and paratype female, Hong Kong, China, Koebele, deposited in the U. S. National Museum. This genus recalls *Arcofacies* but differs in the shape of the frons and in the relative size of the antennae, in the gibbous mesonotum, in the rela-

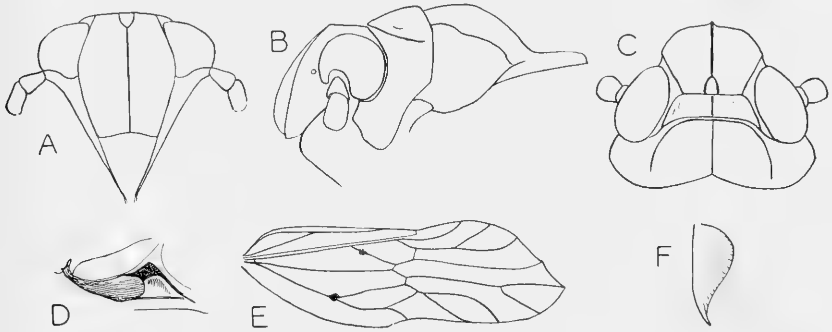


Fig. 7. *Arcofaciella verrucosa*, new genus and species: A, frons and clypeus; B, head and thorax, side view of dorsal half; C, vertex and pronotum; D, striated lobe anterodorsolaterally on third (apparently first) abdominal segment; E, tegmen; F, post-tibial spur.

tively larger pronotum, in the shape of the tegmina and in rostral proportions, and in the absence of a median carina on the clypeus.

The holotype and allotype of *Arcofacies penangensis* Muir are congeneric with *A. verrucosa* and this species must be termed *Arcofaciella penangensis* (Muir) comb. nov. It differs from *A. verrucosa* in its much larger size and in the shape of the frons, which is 1.6 times as long as broad, as contrasted with 1.4; in the less acute apex of the tegmina, and in the following details of the male genitalia: Anal segment with posterior lip deep, with latero-apical angles acute, as contrasted with lip shallow and angles obtuse and less produced; aedeagus with a deep transverse lobe dorsally at base (the corresponding lobe in *A. verrucosa* is much smaller); genital styles in profile strongly constricted in distal third before incurved apex (whereas in *A. verrucosa* from the same viewpoint they appear parallel-sided). The two species differ also in color, *A. penangensis* being much darker.

Tribe **Delphacini** Lambertie

Genus **Sardia** Melichar

Melichar, 1903:96. Haplotype, *Sardia rostrata* Mel.

Sardia rostrata Melichar.
Melichar, 1903:96.

One female, Vinglon District, Cochin-China, French Indo-China, Aug. 6–10, 1934; one female, Chizuka, Okinawa, July–Sept., 1945, G. E. Bohart and C. L. Harnage.

Genus **Nilaparvata** Distant

Distant, 1906:473. Orthotype *Delphax lugens* Stål (=*Nilaparvata greeni* Dist.)

Nilaparvata lugens (Stål).
Delphax lugens Stål, 1854:246.

Two males, Nam-ting-tseun (10 m. N.E. of Sam-ah-Kong), Yai-hsien District, Hainan Island, S. China, Feb. 10–11, 1935. A female from Mai-chan (1 hour by bus more or less west of Ch'ui-man), Suwen District, July 26, 1932, W. E. Hoffman, is referred to this species; one macropterous male, 1,000 m., Suisapa, Lichuan District, W. Hupeh, China, Aug. 20, 1948, Gressitt; eight macropterous males and eighteen macropterous females, Mokansan, Che-Kiang Province, Sept. 6, 1927, Mrs. D. E. Wright, are placed here; the genitalia also agree with figures of *N. oryzae* Mats. Two females, Rivière de Quangtri, Anam, April 30, 1927, Mrs. D. E. Wright, have the median carina of the frons interrupted in the middle of the disc by a transverse sulcus, and may possibly belong to another species.

Nilaparvata muiri China.

(Figure 8, S.)

Nilaparvata (?) *muiri* China, 1925:480.

One male, Chu-Chou Fu, Che-Kiang, China, Sept. 6, 1926, Mrs. D. E. Wright. A female, taken at 1,000 m., Suisapa, Lichuan District, W. Hupeh, China, Aug. 20, 1948, by Gressitt is doubtfully assigned to this species. It differs from *N. muiri* China in the number of lateral spines on the basal segment of the post-tarsus (3) and in the venation of Cu in the tegmen, which is normal. The mesonotum just outside the base of each lateral carina is tumid.

Genus **Phyllodinus** Van Duzee

Van Duzee, 1897:240. Haplotype, *Eurysa nervata* Van Duzee, 1894:191

Phyllodinus luzonensis Muir.

(Figure 8, N, O.)

Muir, 1916:383.

One male and two females, all brachypterous, Rivière de Hue, Anam, Mrs. D. E. Wright, Mar. 16, 1927.

Phyllodinus macaoensis Muir.

(Figure 8, H, I.)

Muir, 1913:246.

One macropterous male and three macropterous females, Rivière de Quangtri, Anam (April 30, May 5, 1927): one brachypterous female, Rivière de Hue, Anam (Mar. 16, 1927), Mrs. D. E. Wright. This series agrees in all details with Muir's description of *P. macaoensis*: the genitalia differ from those of *P. nigromaculosus* Muir in the more tumid lateroapical areas of the anal segment, and in the shorter and stouter and markedly S-shaped genital styles, and in the coloration of the distal portion of the tegmina. The venation of the macropterous tegmina agrees with that described by Muir, though in one specimen the number of branches of Cu is two, not three. The position of the forking of the veins on the corium is variable, and anastomosis in various degrees may occur between Sc and R.

Genus **Dicranotropis** Fieber

Fieber, 1866:530. Logotype, *Delphax hamata* Boheman, 1847:45

Dicranotropis huensis.

(Figure 8, E–G.)

MALE: length, 2.8 mm. FEMALE: length, 2.8 mm. Brachypterous form: Stramineous; disc of frons and intercarinal areas of pronotal disc pale brown; genae below eyes, clypeus, lateral fields of mesonotum, pro- and mesocoxae except at base, a spot on metapleura, abdomen, except laterally, on eighth ventrite, distal margin of pygofer and tenth segment castaneous-piceous. Tegmina dark castaneous-translucent, a spot at middle of claval margin, another at apex of clavus, and a narrow area overlying cross-veins between node and M hyaline or pallid.

Anal segment large, broad, ventral margin transverse, lateral angles produced ventrad in a spine. Pygofer with hind lateral margin in profile sinuate, more or less vertical, medioventrally a small tongue-like process from posterior margin on each side of middle line. Genital styles strongly S-shaped, twisted, broadest a third from apex. Aedeagus strongly laterally compressed, distal portion reflected anteriorly. Diaphragm devoid of ornamentation, dorsal margin shallowly concave.

One male and two females, Rivière de Hue, Anam, Mar. 16, 1927, Mrs. D. E. Wright. This species is distinguished by the shape of the genitalia.

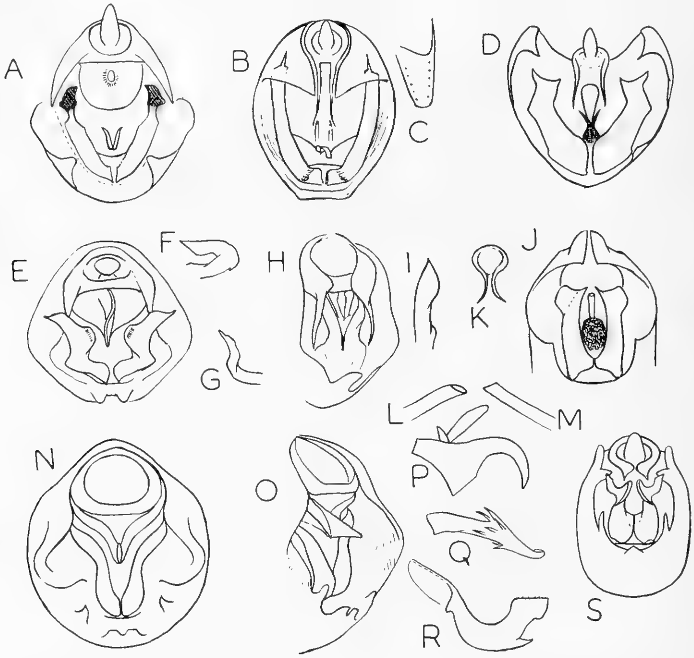


Fig. 8. *Unkanodes sapporona* Mats.: A, male genitalia; P, anal segment of male in profile; Q, aedeagus; R, genital style, lateral view. *Delphacodes inachus*, new species; B, male genitalia; C, aedeagus, lateral view. *Delphacodes shirozui* Ish.: D, male genitalia. *Dicranotropis huensis*, new species: E, male genitalia; F, apical portion of aedeagus; G, apical portion of genital style, lateral view. *Phyllodinus macaoensis* Muir: H, male genitalia, posterolateral view; I, apical portion of genitral style. *Chloriona* (s.) *sirokata* M. & I.: J, male genitalia; K, anal segment of male, posterior view; L, M, aedeagus, left and right sides. *Phyllodinus luzonensis* Muir: N, O, male genitalia ,posterior and posterolateral views. *Unkanodes sapporona* (Mats.): P, anal segment of male in profile; Q, aedeagus, left side; R, left genital style. *Nilaparvata muiri* China: S, male genitalia.

Genus **Chloriona** Fieber

Fieber, 1866:519. Haplotype, *Delphax unicolor* H.-S., 1835:66

The writer recognizes that a wholly satisfactory subdivision of the concept *Chloriona* Muir, which embraces such different species as *Delphax unicolor* H.-S., *Delphax vitticollis* Stål (= *Chloriona turneri* Muir), and *Liburnia slossoni* Ball is likely to prove very difficult to achieve: to judge by material so far examined, it seems likely that one or two segregates can be made, but that these may show the same degrees of variation as found in *Ugyops*. In view of the frequency with which *Delphax furcifera* Horv. appears in literature it seems desirable to anticipate adequate revisionary treatment by segregating this species from the narrow concept of Fieber based on *Delphax unicolor*. It is likely to prove, on critical study, that the gap separating the two concepts is wide, and of generic significance: indeed, if it were merely a case of comparing the respective type species, this could be shown forthwith. As, however, it is not at present possible to bring forward a considered statement of the position of all the species involved, the writer here proposes to go no farther than to establish a new subgenus. For the convenience of students this subgenus is compared with certain existing genera some of which are not represented in the Chinese fauna.

Sogatella Fennah, new subgenus

Head little narrower than pronotum. Vertex slightly longer than broad, its width at base subequal to width of eye in same line, and exceeding two-thirds of its length, apical margin transverse interrupted by projecting submedian carinae of frons; carinae of vertex and frons slender and distinct. Frons longer than broad with median carina forked approximately at level of middle of eyes, lateral margins straight, subparallel. Antennae cylindrical, moderately short, basal segment distinctly longer than broad, second segment longer than first. Rostrum not attaining post-trochanters. Length of pronotum and mesonotum combined scarcely as long as maximum width of latter. Pronotum tricarinate, lateral discal carinae almost straight, strongly diverging basad, not reaching hind margin; not parallel with mesonotal carinae. Mesonotum tricarinate, longer than vertex and pronotum together. Legs terete, not at all compressed, rather slender, post-tibial calcar with about twenty small teeth, basal segment of post-tarsus devoid of spines along side.

Sogatella differs from the typical subgenus in the relatively narrower vertex, which in *Chloriona unicolor* H.-S. considerably exceeds the width of an eye, in the parallel lateral margins of the frons, in the proportions of the frons, in the slightly shorter combined length of the pronotum and mesonotum, and in the fewer teeth on the post-tibial spur, of which there are thirty in the typical subgenotype. *Leptodelphax* Haupt has a relatively longer combined pronotum and mesonotum, while the medial carina of the frons is broadened basally, not forked. *Calligypona* has a relatively longer rostrum. *Kelisia* has a relatively shorter first antennal segment and slightly curved lateral frontal margins, while *Prokelisia* differs entirely in the shape of the head and pronotum.

Type of subgenus, *Delphax furcifera* Horv.

Chloriona (Sogatella) furcifera (Horvath).
Delphax furcifera Horvath, 1899:372.

Five males, nine females, and one mutilated specimen, 1,000 m. Suisapa, Lichuan District, W. Hupeh, China (Aug. 19–24, 1948; 1 male, Rivière de Hue, Anam, Mar. 16, 1927, Mrs. D. E. Wright; 1 male, Tunglu, Sept. 8, 1926, 7 females Mokansan, Che Kiang Province, China, Sept. 6–8, 1927, Mrs. D. E. Wright.

Chloriona (Sogatella) sirokata (M. & I.)
(Figure 8, J–M.)
Sogata sirokata Matsumura & Ishihara, 1945:64.

MALE: length, 2.3 mm.; tegmen, 2.8 mm.

Fuscous; carinae of frons and clypeus, antennae, sides of clypeus, mesoscutellum, legs, and abdomen laterally ochraceous; posterior and ventral margin of pronotum ivory white. Tegmina hyaline, faintly infumed, veins testaceous-brown.

Median carina of frons forked at extreme base on dorsal surface of head. Post-tibial spur with twenty minute teeth.

Anal segment of male with a pair of diverging spines arising at middle of distal margin. Pygofer dorsolaterally much longer than ventrally, produced at dorsolateral angles and incurved, the distal part expanded and truncate parallel with truncate edge of opposite member, medioventral process absent, but a pair of bluntly tooth-like eminences on margin laterad of base of genital styles. Diaphragm thickened and umbonate medially, somewhat roughened. Genital styles moderately broad and flattened, shallowly curved, outer margin sinuate, inner margin concave, outer distal angle broadly and roundly lobate, inner distal angle acuminate. Aedeagus tubular, unornamented, of equal width throughout, and with orifice apical, oblique.

Two males, Rivière de Hue, Anam, Mar. 16, 1927 (Mrs. D. E. Wright).

Genus **Delphacodes** Fieber

Fieber, 1866:524. Logotype *Delphax mulsanti* Fieber, 1866:526

Delphacodes terryi Muir.
Muir, 1917:334.

Two macropterous males, Honam Island, Canton, China, May 4, 1932; White Cloud Mountain, Canton, China, Mar. 19, 1933.

Delphacodes shirozui Ishihara.

(Figure 8, D.)

Ishihara, 1949:53.

Median carina of frons forked at level of incipient curve into vertex. Post-tibial spur with sixteen teeth.

Anal segment small, a pair of long slender spines arising on each side of middle line on hind margin. Pygofer dorsally deeply emarginate, dorsolateral angles produced caudad, distally incurved, medioventral process absent, diaphragm armed medially with a bispinose sclerite. Genital styles sinuate on outer margin, concave on inner, apical angles bluntly pointed, distal margin shallowly concave. Aedeagus basally compressed, distally subcylindrical.

Two males, Lau-Chi, Che-Kiang, China, June 20, 1926, Mrs. D. E. Wright.

Delphacodes inachus Fennah, new species.

(Figure 8, B, C.)

MALE: length, 1.8 mm.; tegmen (brachypterous), 1.1 mm.

Vertex with median carina forked at base, on horizontal dorsal area. Antennae attaining level of frontoclypeal suture. Post-tibial spur with about eighteen teeth, basitarsus with an oblique row of five teeth and two separate teeth at proximal end of oblique row. Rostrum slightly surpassing mesotrochanters.

Fuscous-piceous; a few spots on apex of frons and anterior half of genae fuscous; carinae of vertex, frons, and clypeus, lateral fields of pronotum, and a broad line overlying median carina of pronotum and mesonotum pallid to white; disc of vertex, antennae, posterior area of genae and sides of clypeus, legs, except post-tibiae at base, abdomen at sides, and a ring around anal emargination of pygofer, testaceous.

Anal segment of male small, deeply sunk in emargination, with a pair of slender spines arising near middle line, directed ventrad. Pygofer narrowly but deeply emarginate above, laterodorsal angles broadly produced and inflected mesad, bluntly rounded, so that the cavity of the pygofer in posterior view is heart-shaped, a slight lenticular swelling in middle of lateral margin; medioventral process absent; diaphragm with armature carried near ventral margin of foramen, in form of a short lobe projecting caudad. Styles long, vertical, slightly swollen at base, slightly curved, produced in a spine at apex. Aedeagus V-shaped, much laterally compressed, widened near middle, acuminate distally.

One brachypterous male, **Suisapa, Lichuan District, W. Hupeh, China,** July 23, 1948, Gressitt. This species is distinguished by the shape of the genitalia.

Unkanodes Fennah, new genus

Rather slender. Head little narrower than pronotum. Vertex longer than broad, its width at base not exceeding width of an eye, shallowly rounded at apical margin; carinae of vertex and frons distinct. Frons longer than broad, with median carina forked only at extreme base. Antennae cylindrical, basal segment two and a half times as long as broad, at least half as long as second. Length of pronotum and mesonotum combined equal to maximum width of latter. Pronotum tricarinate, lateral discal carinae almost straight; very weakly curved laterad, not reaching hind margin and not in line with mesonotal carinae. Mesonotum longer than head and pronotum together, tricarinate. Legs terete, not at all compressed, post-tibial calcar with about twenty-two teeth, basal segment of post-tarsus devoid of spines.

Type species, *Unkana sapporona* Mats.

Unkanodes sapporona (Mats.).
(Figure 8, P–R.)
Unkana sapporona Matsumura, 1935:74.

One male, Mokansan, Che-Kiang Province, China, probably collected by Mrs. D. E. Wright. The genitalia are figured.

This species, which has recently been transferred to *Delphacodes* by Ishihara (using *Delphacodes striatella* Fall. as the basis of reference for generic characters), is separated from *Delphacodes* by the characters given in the key above and from *Sogata* (interpreted strictly from the holotype of *S. dohertyi* Dist.) in the shorter vertex and frons and relatively very much shorter clypeus.

Family **MEENOPLIDAE** Muir

KEY TO GENERA OF CHINESE MEENOPLIDAE
(Adapted from Muir)

(1) (2) Claval veins uniting near apex of clavus; first claval vein strongly granulate; second not or weakly so, subparallel to commissural margin..(3)
(2) (1) Claval veins uniting near middle of clavus; first claval vein not granulate, second strongly so, curved........*Anigrus* Stål
(3) (4) Clypeus devoid of lateral carinae........*Nisia* Mel.
(4) (3) Clypeus laterally carinate........*Eponisia* Mats.

Genus **Nisia** Melichar

Melichar, 1903:53. Haplotype, *Meenoplus atrovenosus* Leth.

Nisia atrovenosa (Leth.).
(Figure 9, A–C.)
Meenoplus atrovenosus Lethierry 1888:466.

One female, Cheung-Mu-Tsang, 50 km. northwest of Chungking, China, on citrus, Gressitt, July 8, 1948; 1 mutilated specimen, Rivière de Quangtri, Anam, Mrs. D. E. Wright, April 30, 1927; 1 male, 1 female, Rivière de Hue, Anam, Mrs. D. E. Wright, March 16, 1927; 7 females and 7 mutilated specimens, Tunglu, Che-Kiang Province, Mrs. D. E. Wright, Sept. 8, 1926; one female, same locality, Mrs. D. E. Wright, Sept. 10, 1926; 1 mutilated specimen, Mokansan, Che-Kiang Province, Mrs. D. E. Wright, Sept. 10, 1927.

Nisia suisapana Fennah, new species.
(Figure 9, D–F.)

Female: length, 2.2 mm.; tegmen, 3.0 mm.

Tegmina 2.1 times as long as broad, broadest at level of stigma, anterior margin convex, not indented at node, anterior branch of M simple at apex; post-tibiae 8-spined at apex, basal metatarsal segment 7-spined, second metatarsal segment with 5 spines.

Stramineous, probably powdered white in life, abdomen pale fuscous, eyes and spines on legs black. Tegmina sordid white marked with pale fuscous as figured. Wings white, veins pallid.

Third valvulae of ovipositor in profile with dorsoapical lobe well developed, about as broad as long.

One female, **1,000 m. Suisapa, Lichuan District, W. Hupeh, China,** Gressitt, Aug. 20, 1948. This species differs from all others in the tegminal markings: it is superficially nearest to *N. albovenosa* Dist.

Genus **Eponisia** Matsumura

Matsumura, 1914:285. Orthotype, *Eponisia guttula* Mats.

Eponisia guttula Mats.
Matsumura, 1914:286.

Post-tibiae 8-spined at apex, basal metatarsal segment 7-spined, second metatarsal segment 6-spined.

One female, Mokansan, Che-Kiang Province, Mrs. D. E. Wright, Sept. 6,

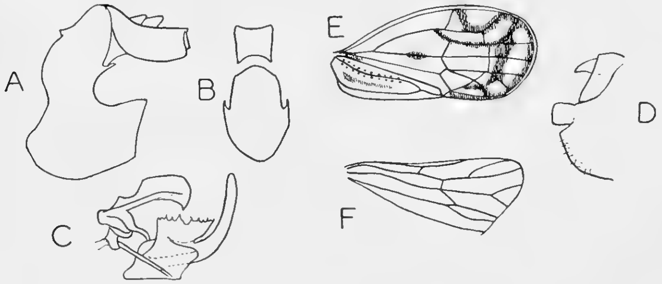


Fig. 9. *Nisia atrovenosa* Leth.: A, anal segment and pygofer, left side; B, ditto, posterior view; C, aedeagus, left side. *Nisia suisapana*, new species: D, anal segment and external genitalia of female, right side; E, tegmen; F, anterior portion of wing.

1927, is considered to be a geographical representative of this species. The infuscate markings on the tegmina are very pale.

Genus **Anigrus** Stål

Stål, 1866:172. Logotype, *Anigrus sordidus* Stål, 1866:173

Anigrus nigricans (Mats.).

Paranisia nigricans Matsumura 1914:285.

Post-tibiae 8-spined, basal metatarsal segment 6-spined, second metatarsal 5-spined. Tegmina with anterior margin yellowish-brown, apical and commissural margins fuscous.

One female, Mizuho, Formosa, Gressitt, April 22, 1932.

Family **KINNARIDAE** Muir

Genus **Kinnara** Distant

Kinnara, Distant, 1906:39. Orthotype, *Pleroma ceylonica* Melichar, 1903:42
Pleroma Melichar, 1903:41

Kinnara fumata Mel.

Melichar, 1903:42.

One male, 1,000 m., Suisapa, Lichuan District, W. Hupeh, July 25, 1948. Gressitt.

Family **DERBIDAE** Spinola

KEY TO GENERA OF CHINESE DERBIDAE

(1) (2) Tegmina with clavus closed, second cubital vein reaching hind margin directly, frons narrow, not strongly laterally compressed........(3)

(2) (1) Tegmina with clavus open; second cubital vein curving into subapical transverse line of cross veins: frons strongly laterally compressed....(5)

(3) (4) Pronotum with a distinct median disc bounded laterally by carinae; frons little longer than broad, margins convex, antennae and apical segment of rostrum long........*Vinata* Dist.

(4) (3) Pronotum without a distinct median disc, frons much longer than broad, margins concave, antennae and apical segment of rostrum short........*Vekunta* Dist.

(5) (6) Wings not more than half as long as tegmina, usually narrow or reduced with stridulary organ on reduced anal lobe........(7)

(6) (5) Wings more than half as long as tegmina, ampliate........(15)

(7) (8) Tegmina with all median sectors single, usually 6; antennae usually shorter than frons........(9)

(8) (7) Tegmina with five median sectors, one furcate........(11)

(9) (10) Basal median cell narrow, wings about half as long as tegmina, apex rounded; antennae much shorter than frons........*Proutista* Kirk.

(10) (9) Basal median cell wide and short, not more than 3.5 times as long as broad, wings much less than half as long as tegmina, acute at apex.................... *Diostrombus* Uhl.

(11) (12) Second or third median sector forked, base of clypeus in profile straight .... *Pamendanga* Dist.

(12) (11) First median sector with two to four branches.................... (13)

(13) (14) Posterior margin of tegmina undulate.................... *Losbañosia* Muir

(14) (13) Posterior margin of tegmina not undulate.................... *Zoraida* Kirkaldy

(15) (16) Tegmina less than 2.5 times as long as broad, clavus closed or nearly so .... *Rhotana* Wlk.

(16) (15) Tegmina more than 2.5 times as long as broad, clavus open.................... (17)

(17) (18) Media arising from radius distad of Sc + R + M fork; lateral carinae of vertex and frons very large.................... *Megatropis* Muir

(18) (17) Media arising from R or basad of Sc + R fork.................... (19)

(19) (20) Sc + R fork at or basad of middle of tegmen, subcostal cell elongate in profile, vertex and frons meeting in a distinct angle.... *Kamendaka* Dist.

(20) (19) Sc + R fork distad of middle, subcostal cell short, in profile head broadly ovate, no evident point of union of vertex and frons............ *Vivaha* Dist.

Genus **Losbañosia** Muir

Muir, 1917:85. Haplotype, *Losbañosia bakeri* Muir

Losbañosia bakeri Muir.

Muir, 1917:86.

One female, Lung-Tau Shan, N. Kwangtung, China, Gressitt, June 11, 1947.

Genus **Diostrombus** Uhler

Uhler, 1896:283. Haplotype, *Diostrombus politus* Uhl.

Diostrombus politus Uhl.

Uhler, 1896:284.

Post-tibiae 4-spined at apex, basal metatarsal segment 7-spined, second metatarsal 9-spined.

Twenty-five males and 23 females, Cheung-Mu-Tsang, 50 km. northwest of Chungking, China, July 8, 1948, Gressitt. It is evident from the collection data that adults were "swarming" at the time of collection.

Genus **Zoraida** Kirkaldy

Kirkaldy, 1900:242. Orthotype, *Derbe sinuosa* Boheman, 1838:225

Zoraida kirkaldyi Muir.

(Figure 11, A–E.)

Muir, 1918:205.

Lateral submargins of frons each longitudinally shallowly sulcate so that frons between eyes is more than two-thirds width of an eye in frontal view. Post-tibiae with 1 spine laterally, 5 apically, basal metatarsal segment 6-spined at apex, second metatarsal 6-spined.

Two males and 1 mutilated specimen, 1,000 m., Suisapa, Lichuan District, W. Hupeh, China, August 20, 1948, Gressitt.

Genus **Pamendanga** Distant

Distant, 1906b:298. Orthotype, *Pamendanga rubilinea* Dist., 1906:299

Pamendanga sauterii Muir.

Paraproutista sauterii Muir, 1915:131.

Aedeagus broad, shallowly scoop-like; ventrally on right a moderately short spine curved laterad and caudad, a large thin elongate triangular lobe, acuminate at tip, directed caudad at apex of aedeagus, a spine dorsolaterally on left a little before apex, directed anteriorly, ventrally, in posterior view, a pair of short triangular eminences slightly to left of middle line.

Post-tibiae unarmed at sides, with 5 spines at apex, basal metatarsal segment 4-spined, second metatarsal segment 3-spined.

One male (mutilated) and 2 females (one mutilated), 1,000 m., Suisapa, Lichuan District, W. Hupeh, China; male, July 23; females, July 23, 25, 1948, Gressitt.

Genus **Rhotana** Walker

Walker, 1857:160. Haplotype, *Rhotana latipennis* Walker, 1857:160

Rhotana maculata Mats.

(Figure 10, D.)

Matsumura, 1914:295.

Post-tibiae 4-spined at apex, basal metatarsal segment 5-spined, second metatarsal 4-spined.

One male, Mokansan, Che-Kiang Province, Mrs. D. E. Wright, Sept. 16, 1927. This identification requires confirmation. The specific characters of the tegminal venation are figured.

Rhotana satsumana Mats.

(Figure 10, A, B, E.)

Matsumura, 1914:294.

Two mutilated specimens, Mokansan, Che-Kiang Province, Mrs. D. E. Wright, Sept. 6, 10, 1927.

In the material before the writer the lateral carinae of the frons are strongly divergent and actually separated from the level of the lower margin of the eye.

Rhotana satsumana contracta Fennah, new subspecies.
(Figure 10, C.)

Female: length, 3.3 mm.; tegmen, 6.0 mm.

Lateral margins of frons contiguous to well below level of eyes, not strongly divergent until below level of antennae. Tegmina with basal venation of M and Cu as figured. Posterior margin of pregenital sternite triangularly produced medially, subrectangulate at apex.

Stramineous, powdered pallid. Tegmina translucent, powdered white, basal third except in middle of intervenal areas, an arcuate fascia from middle of costal margin to apex of clavus subparallel to apical margin of tegmen, a narrow band on each side of, though separated from, apical line of transverse veins passing posteriorly into a large suffusion, pale fuscous; veins yellow, red where transversing infuscate or pigmented areas. A yellow suffusion bordering subapical line of transverse veins in anterior four cells. Wings infumed pale fuscous, white along apical margin, a short arcuate dark spot interrupted by union of M–Cu cross vein and Cu_{1a}.

Described from one female, **1,000 m., Suisapa, Lichuan District, W. Hupeh, China,** July 24, 1948, Gressitt. This subspecies is distinguished by the shape of the lateral carinae of the frons and by the tegminal venation. A single female from Hainan Island (*en route* Cheung-kon-ts'uen to Tai pin-ts'uen, Kiung-Shan District, July 19, 1935) is doubtfully ascribed to this species; its points of difference (in tegminal venation and the shape of the black spot on the wings) are figured to facilitate recognition.

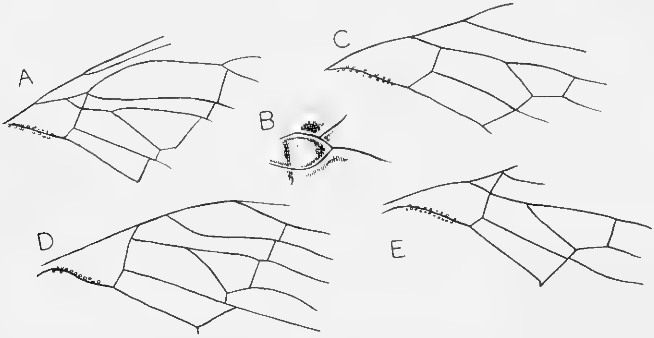


Fig. 10. *Rhotana satsumana* Mats.: A, tegminal venation at base of *M* (Hainan Island specimen); B, spot on wing (Hainan Island specimen); E, tegminal venation in *M* (Mokansan specimen); C, *contracta*, new subspecies, tegminal venation in *M*. *Rhotana maculata* Mats.: D, tegminal venation at base of *M*.

Genus **Vivaha** Distant

Distant, 1906b:307. Orthotype, *Vivaha facialis* Dist.

Vivaha facialis Dist.
(Figure 13, A–C.)
Distant, 1906b:308.

Post-tibiae with 6 spines at apex, basal metatarsal segment 4-spined, second metatarsal segment bispinose.

One male and 1 female, 1,000 m., Suisapa, Lichuan District, W. Hupeh, China, Gressitt, Aug. 19, 1948.

Genus **Megatropis** Muir

Muir, 1913:57. Orthotype, *Megatropis coccineolinea* Muir, 1913:57

Megatropis formosana (Mats.).
Mesotiocerus formosanus Matsumura, 1914:301.

Post-tibiae 6-spined at apex, basal metatarsal segment 4-spined, second metatarsal 2-spined.

One mutilated male and 7 females, 1,000 m., Suisapa, Lichuan District, W. Hupeh, China, July 23, 24; Aug. 23, 1948, Gressitt. The series agrees so closely with Matsumura's description and figures that no subspecific differentiation is apparent.

Genus **Kamendaka** Distant

Distant, 1906b:310. Orthotype, *Kamendaka spectra* Dist.

Kamendaka spectra Dist.
(Figure 11, F, G.)
Distant, 1906:311.

Post-tibiae laterally unarmed, apically with 5 spines; basal metatarsus 6-spined, second metatarsus 5-spined.

One male taken on ridge, 1,200–1,500 m., Suisapa, Lichuan District, W. Hupeh, China, July 25, 1948, Gressitt.

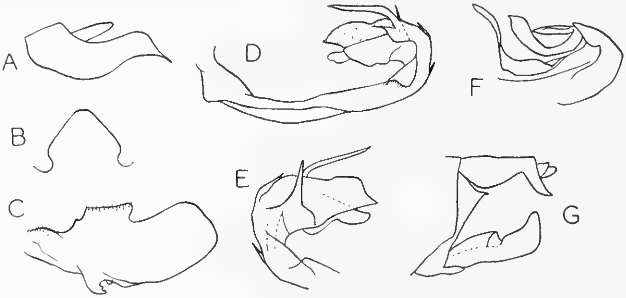


Fig. 11. *Zoraida kirkladyi* Muir: A, anal segment of male, side view; B, medioventral process of pygofer; C, genital style; D, aedeagus, left side; E, apex of aedeagus, right side. *Kamendaka spectra* Dist.: F, apical portion of aedeagus, left side; G, anal segment, pygofer, and left genital style.

Kamendaka (Eosaccharissa) nigromaculata Dist.
Chaprina nigromaculata Distant, 1911:645.

Post-tibiae laterally unarmed, apically with 11 spines, basal metatarsal segment 9-spined, second metatarsal segment 8-spined.

One male and two females, Rivière de Hue, Anam, Mar. 16, 1937, Mrs. D. E. Wright.

Genus **Vekunta** Distant

Distant, 1906:8. Orthotype, *Vekunta tenella* Melichar, 1903:41

KEY TO SPECIES OF VEKUNTA

(1) (2) Tegmina unicolorous, subopaque, pallid yellowish or creamy white....(3)

(2) (1) Tegmina infuscate or with dark suffusion, or with fuscous markings....(7)

(3) (4) Wings white, or subhyaline powdered white....(5)

(4) (3) Wings infuscate with darker veins. Philippine Islands....*V. palawanensis* Muir

(5) (6) A fuscous-piceous spot on propleura; wings white with white veins. Formosa?....*V. albipennis* Mats.

(6) (5) No dark spot on propleura; wings hyaline-white with veins distally greyish brown. China....*V. nivea*, new species

(7) (8) Tegmina subhyaline, sordid white, veins pallid, most cells suffusedly bordered with pale sepia-brown. Formosa....*V. lyricen*, new species

(8) (7) Tegmina not as above....(9)

(9) (10) Tegmina pale, conspicuously bordered fuscous or fuscous piceous along costal margin and sutural margin, or at least along sutural margin of clavus, often with apical margin also dark in part....(11)

(10) (9) Tegmina without distinct marginal infuscation as above, usually with a general rather dark ground color, occasionally of light hue....(17)

(11) (12) Tegmina with a piceous mark over subcostal cell and apex of costal cell. Formosa....*V. nigrolineata* Muir

(12) (11) Tegmina not marked as above....(13)

(13) (14) Tegmina with a narrow fuscous band from radial cross vein to apex, apical margin fuscous....(15)

(14) (13) Tegmina without such band in R....(43)

(15) (16) Tegmina with costa dark fuscous. Java....*V. hyalina* Muir

(16) (15) Tegmina with corium and veins anterior to R milky-white....*V. nigrinervis* Schmidt

(17) (18) Tegmina subhyaline, tinged yellow, with yellowish veins, stigma hyaline, a small dark spot near apex of costa, apical veins infumed at tip, apical margin infuscate in female. Formosa....*V. maculata* Mats.

(18) (17) Tegmina more or less generally suffused fuscous, or very dark....(19)

(19) (20) Tegmina piceous, costa yellowish, a small yellow spot at stigma. Assam....*V. flavipes* Muir

(20) (19) Tegmina not piceous, and not so marked....(21)

(21) (22) Tegmina with costal cell, at least anteriorly, pallid for most of its length; remainder of corium infuscate....(23)

(22) (21) Costal cell wholly infuscate, or infuscate to near apex........(27)

(23) (24) A black spot on propleura laterally. Ceylon........*V. punctula* Mel.

(24) (23) No black spot on propleura........(25)

(25) (26) General body color yellow; tegmina brownish yellow, disc of vertex not hollowed or markedly depressed. Ceylon........*V. tenella* Mel.

(26) (25) General body color castaneous; tegmina dark brown with a pallid oblong fleck at node; disc of vertex rectangulately hollowed out. Formosa........*V. stigmata* Mats.

(27) (28) Tegmina with a dark spot adjoining a pallid spot at costal margin........(29)

(28) (27) Tegmina unicolorous, or if with a pallid spot, with no dark spot adjacent to it........(31)

(29) (30) A hyaline spot on costal margin at node, a piceous spot just distad of it, and an oblique pallid stripe adjoining. Sumatra........*V. nitida* Bierm.

(30) (29) A yellowish patch at end of costal cell, reaching from costa to media, with a dark spot in middle of it........*V. badia* Muir

(31) (32) Tegmina unicolorous, translucent brown........(33)

(32) (31) Tegmina paler at, or near, stigma, or if not then with veins very dark, but paler distally........(35)

(33) (34) Mesopleura fuscous; transverse carinae of vertex testaceous; legs yellow with tibiae apically and tarsi medially and apically black. Formosa........*V. botelensis* Mats.

(34) (33) Pleura with a round black spot; carinae of vertex fuscous, legs yellowish. Formosa........*V. makii* Muir

(35) (36) Mesonotum light brown on disc, darker laterally........(37)

(36) (35) Mesonotum fuscous-piceous or black........(41)

(37) (38) Vertex 1.5 times as long as broad; tegminal veins sordid yellow. Formosa........*V. shirakii* Mats.

(38) (37) Vertex as long as broad, or if not, then tegminal veins dark fuscous........(39)

(39) (40) Tegminal veins sordid yellow; anal segment of male terminating in a small point. Japan and China........*V. malloti* Mats.

(40) (39) Tegminal veins dark fuscous; anal segment of male slightly emarginate at apex. Formosa........*V. umbripennis* Muir

(41) (42) Tegmina with a small pale translucent spot at apex of costal cell; veins unicolorous throughout. Java........*V. pseudobadia* Muir

(42) (41) Tegmina fuscous; veins very dark, paler toward apex. Formosa........*V. atripennis* Mats.

(43) (44) Clypeus with a black spot in middle; a black spot on propleura; margins of tegulae dark. Philippine Islands........*V. lineata* Mel.

(44) (43) Clypeus without a black spot in middle; an oval black spot on both propleura and metapleura. Formosa........*V. kotoshonis* Mats.

Vekunta nivea Fennah, new species.

(Figure 12, A–E.)

Male: length, 3.5 mm.; tegmen, 4.9 mm. Female: length, 3.0 mm.; tegmen, 4.5 mm.

Vertex across base 1.33 times length in middle line. Post-tibiae unarmed laterally, 7-spined at apex, basal metatarsal segment 6-spined, second metatarsal segment 6-spined.

Stramineous; mesonotum and pregenital sternite tinged yellowish brown, a fuscous-piceous spot on mesothoracic pleurites, a paler fuscous spot laterally on metathoracic pleurites, apical segment of rostrum pale, its apical disc black. Tegmina hyaline, entire membrane distad of stigma faintly suffused with yellow, veins pallid, faintly yellow in membrane, anterior part of apical margin faintly tinged orange. Wings hyaline, veins greyish-brown distally. Insect in life powdered white.

Pregenital sternite of female shallow, transversely sulcate, distally produced and directed upward in a broad subtriangular process of the shape figured.

Anal segment of male long, narrow, broadly longitudinally sulcate, apically deflexed and recurved below to point cephalad. Aedeagus dorsally with a short medial spine at base directed upward and to left, a long medial spine at apex directed cephalad with a minute tooth on left at its base; on right side a long sinuate spine directed caudad, at apex of flagellum a short tooth-like plate directed upward and cephalad. Genital styles long, curved dorsad and mesad distally, of subequal width throughout, a pyramidal eminence applied to inner face at middle, this eminence terminating dorsally in a single blunt tooth, ventral angles setose-toothed.

Described from 1 male and 4 females, **Mokansan, Che-Kiang Province, China,** Mrs. D. E. Wright, Aug. 29, Sept. 16, Sept. 22, 1927.

This species is distinguished by the combined characters of a pitchy mesothoracic spot, and generally pallid color.

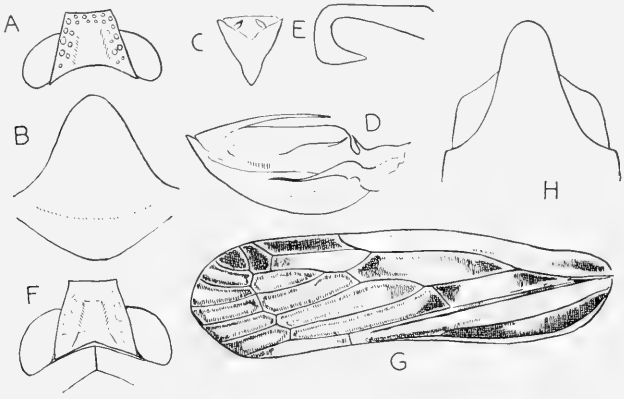


Fig. 12. *Vekunta nivea*, new species: A, vertex; B, pregenital sternite of female; C, apex of anal segment of male, posterior view; E, ditto, side view; D, aedeagus, side view. *Vekunta lyricen*, new species: F, vertex; G, tegmen; H, pregenital sternite of female.

Vekunta lyricen Fennah, new species.
(Figure 12, F–H.)

Female: length, 3.5 mm.; tegmen, 5.1 mm.

Reddish-brown; lateral margins of frons, apex of rostrum, a band adjoining median carina of mesonotum on each side, abdomen and genitalia, fuscous; pronotal disc, a broadening band from eye to and across tegula, a longitudinal submedian band on mesonotum, pallid yellow, mesoscutellum salmon-pink, tibiae and tarsi testaceous-fuscous.

Tegmina greyish-hyaline, veins pallid, most cells incompletely but clearly bordered sepia. Wings rather sordid white, veins concolorous basally, pale sepia distally.

Pregenital sternite produced in a narrowly triangular process, almost semicircularly rounded at apex, directed caudo-dorsad.

One female, 1,000 m., **Musha (Wuse) to Bandai, Taichung District, Formosa,** Gressitt, August 24, 1947. This species does not possess any obvious spot on the mesothoracic pleurites, and the tegminal markings do not agree with those of any species so far described in the genus.

Genus **Vinata** Distant

Distant, 1906a:8. Orthotype, *Erana operosa* Walker, 1857:151

Vinata sp. nr. **nigricornis** Stål.

One female, Lu-ling-paai, Yaoshan, Lin-Hsien District, Kwangtung, Oct. 1–2, 1924.

Post-tibiae 7-spined at apex, basal metatarsal segment 6-spined, second metatarsal 6-spined.

Family **ACHILIDAE** Stål

KEY TO GENERA OF CHINESE ACHILIDAE

(1) (2) Pronotal disc elongate, three-quarters length of mesonotum, no median carina on mesonotum; hind wing markedly notched at Cu_2........................ *Rhotala* Walk.

(2) (1) Pronotal disc relatively shorter, mesonotum medially carinate, apical margin of hind wing entire........................(3)

(3) (4) Vertex less than two-thirds as wide as pronotum; tegmina with numerous apical longitudinal veins........................*Faventilla* Metc.

(4) (3) Vertex at least two-thirds as wide as pronotum; tegmina with about seven apical veins at margin distad of Sc........................(5)

(5) (6) Width of vertex measured at base of middle line at least twice length along middle; M_{1-2} forking at apical transverse line........................ *Plectoderoides* Mats.

(6) (5) Width of vertex not twice length along middle........................(7)

(7) (8) Vertex devoid of a carina across apex, or with median carina prominent and apical transverse carina obsolete........................(9)

(8) (7) Vertex with one or more distinct carinae at apex .... (11)

(9) (10) Vertex not distinctly produced before eyes, about as wide at apex as at base, lateral discal carinae of pronotum concave, curved laterad, not reaching hind margin .... *Tangina* Mel.

(10) (9) Vertex not as above, lateral discal carinae of pronotum straight, reaching basal margin .... *Akotropis* Mats.

(11) (12) Vertex with a single distinct carina across apex .... (13)

(12) (11) Vertex with two transverse carinae between frons and vertex, confluent in middle but separating sublaterally to enclose a more or less distinct triangular facet .... (17)

(13) (14) Vertex 3 times as wide across base as long in middle line.. *Zathauma* Fenn.

(14) (13) Vertex relatively narrower .... (15)

(15) (16) Vertex produced before eyes for one- to two-thirds length of eye, in profile meeting frons acutely, lateral carinae of frons not as eminent as median carina, almost meeting acutely at base .... *Betatropis* Mats.

(16) (15) Vertex produced before eyes for scarcely half their length, in profile meeting frons subrectangulately, lateral carinae of frons more prominent than median carina .... *Caristianus* Dist.

(17) (18) Vertex medially carinate throughout, disc little depressed, if at all; tegmina with Sc and R together with six or seven veinlets at margin near stigma; no transverse callus on mesonotal disc .... *Usana* Dist.

(18) (17) Vertex medially carinate only in basal two-thirds, or less, lateral margins strongly raised; mesonotum with a transverse callus on anterior third of disc, tegminal venation not as above .... *Magadha* Dist.

Genus **Faventilla** Metcalf

Metcalf, 1948:60. Orthotype, *Cixius pustulatus* Walker, 1857:146

Faventilla spp.

One mutilated specimen, 250–300 m., Tao-kok-wan, Lung tau Shan, Kwangtung Province, S. China, Sept. 6, 1947, Gressitt. Dr. China, who kindly compared this and the following with Walker's types in the British Museum, points out that this "comes closest to *F. pustulata* Walker but

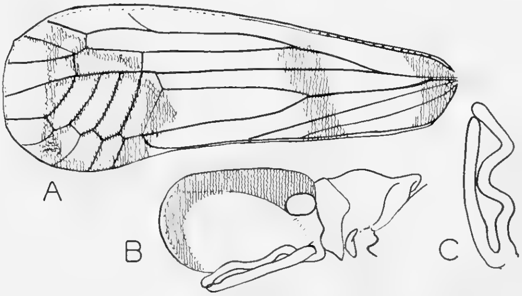


Fig. 13. *Vivaha facialis* Dist.: A, tegmen; B, head in profile; C, antenna.

differs in the venation (Sc + R stalk being much shorter), in the absence of the three black spots on the tegmen and of the large black spot on the side of the propleuron."

One female, 2,800 ft., Big Pool, Loh Fau Shan, Kwangtung, Oct. 13, 1935, E. R. Tinkham, "resembles *F. guttifer* Walker in size and color, particularly the pale greenish-yellow color. It differs, however, in the much shorter anteriorly-rounded vertex. In *F. guttifer* Walker the vertex is nearly as long as wide at base with the anterior margin angulate where the midfacial carina meets it."

Genus **Usana** Distant

Distant, 1906:293. Orthotype, *Usana lineolalis* Dist.

Usana lineolalis Dist.
Distant, 1906:294.

Male: length, 3.0 mm.; tegmen, 4.5 mm. Female: length, 3.5 mm.; tegmen, 5.0 mm.

Stramineous to testaceous, a linear mark on each side of middle line of vertex, a round spot on lateral lobes of pronotum, a spot on tegulae and on mesopleura, a faint spot on mesonotal disc near base of lateral carinae fuscous. Tegmina yellowish-translucent, powdered grey, stigmal cells and all apical cells at margin fuscous, veins concolorous, stigmal veins and apical veins near margin ivory-white. Wings slightly infuscate, veins fuscous.

Post-tibiae 7-spined at apex, basitarsus 7-spined distally, second posttarsal segment 6-spined.

Anal segment short, broad, lateral margins convex, apical margin excavate, lateroapical angles produced and deflexed. Pygofer with a short finger-like process laterally on hind margin near anal segment. Genital styles broad bearing at middle of dorsal margin a trispinose lobe. Aedeagus subtubular, flattened on dorsal surface, keel-like below, a spine arising at apex in middle line directed ventrocephalad below aedeagus; laterally at apex a flange-like lobe projecting laterad; on right a pair of vertical lobes, one overlapping the other, both concave on anterior margin.

Twelve males, 13 females and 3 mutilated specimens, Mokansan, Che Kiang Province, China, Aug. 24–Sept. 19, 1927, Mrs. D. E. Wright.

One female, Tai-ka, Tin-tong, Loh-chang District, Kwangtung, S. China, Aug. 18, 1947. The series differs from the type only in the less definite mottling of the corium along the veins.

Genus **Magadha** Distant

Distant, 1906:290. Orthotype, *Cixius flavisigna* Walker, 1851:348

Magadha metasequoiae Fennah, new species.

Female: length, 4.8 mm.; tegmen, 6.8 mm.

Tegmina with costal vein close to margin throughout. Fuscous; vertex, except for a spot in each half of disc, about seven spots laterally on frons and a diffuse transverse bar across middle, clypeus broadly at base, narrowly at apex, disc and carinae of pronotum, dorsal half of tegulae and lateral angles of mesonotum, femora at base and apex, tibiae at base, middle and apex, and posterolateral margins of abdominal ventrites, ivory-yellow to stramineous; a sprinkling of small round spots on disc of frons testaceous. Tegmina ivory-hyaline, about eight marginal spots in costal cell, two of which are included in a broad fascia extending across to second claval vein, a broken diffuse fascia from fork of Cu_1 to stigma, apical cells of Sc, R and M at least at margin and a narrow interrupted fascia following distal cross-veins, fuscous or fuscous-piceous. Wing infuscate, veins fuscous.

Seventh sternite transverse posteriorly, tumid sublaterally, and with an eminence medially, hollowed out on its posterior face.

Eighth segment with ventro-lateral pieces directed medially, tapering to bluntly-rounded apex.

Post-tibiae with a single spine near base, six short teeth and one long at apex, basal metatarsus with six apical teeth, second metatarsal also with six.

One female collected from *Metasequoia glyptostroboides,* **1,000 m. Suisapa, Lichuan District, W. Hupeh, China,** Aug. 21, 1948, Gressitt. This species is distinguished from all described species of *Magadha* by coloration and from *Kempiana maculata* Muir by the absence of a pre-costal area in the tegmen, by coloration of the tegmina, and by size.

Magadha denticulata Fennah, new species.

(Figure 14, A–D.)

Male: length, 3.6 mm.; tegmen, 5.0 mm. Female: length, 3.2 mm.; tegmen, 5.0 mm.

Vertex about 1.5 times as broad across base as long in middle line. Tegmina with Sc + R fork slightly distad of Cu_1 fork, $M_1 + 2$ not forked before distal transverse line of cross veins. Post-tibiae with a tooth laterally in basal third, seven-toothed at apex, basal metatarsal segment 7-toothed, second metatarsal 6-toothed.

Fuscous; vertex at base and apex, six spots on each lateral margin of frons and a short transverse bar one-fifth from apex, clypeus at base and apex, carinae of pronotum, lateral angles of mesonotum and apex of scutellum, femora at apex, and tibiae at middle and apex stramineous or pallid ochraceous, mesonotal disc with a pair of more or less distinct ocellate spots at basal third. Tegmina sordid ochraceous, veins including costa, pale regularly spotted with fuscous, two spots in costal cell, stigma, apex of clavus, and apical cells at base and apex, fuscous. Wings infuscate, veins darker.

Anal segment of male triangular, slightly broader than long, Pygofer with lateral margin with a semilunate lobe, medioventral process bifid, each lobe acuminate. Aedeagus produced laterally on left side at base in a short plate, toothed on margin, medially and dorsally at base a vertical plate, slightly inclined to right, phallobase distally broad, produced laterally on right in a subtriangular process, toothed at its apex.

Posterior margin of seventh sternite transverse. Ventrolateral angle of posterior margin of eighth segment in ventral view only slightly acute.

Two males (one the type) and six females, **1,000 m. Suisapa, Lichuan District, W. Hupeh,** Aug. 20–24, 1948, Gressitt. In this species the laterobasal facets of the frons are very feebly demarcated on their ventral margin. In the males there is a feeble round impression; the texture of the anterior third of the mesonotum differs from that of the posterior two-thirds. The species differs from typical *Magadha* and also from *Francesca* in venation, as $M_1 + 2$ does not fork basad of the distal transverse line. From *Francesca* it also differs in the broader vertex. It is close to *M. formosana* Mats.

One male, 250–350 m., Tso-kok-wan, Lungtau Shan, Kwangtung Province, June 9, 1947, Gressitt is also placed here.

Magadha cervina Fennah, new species.

(Figure 15, A–E.)

MALE: length, 3.0 mm.; tegmen, 4.0 mm.

Laterobasal triangular facets of frons moderately distinct. Post-tibiae laterally unispinose, apically 8-spined, basal metatarsal segment 7-spined, second metatarsal 6-spined.

Reddish-brown; six spots along lateral margins of frons, apex of clypeus, a spot on sides of clypeus, pronotal areolets, a stripe on post-tibiae near base, fuscous; hind legs otherwise stramineous. Tegmina translucent, powdered sordid greyish-yellow, veins concolorous, regularly spotted fuscous, a few small round spots in membrane, apical cells at base and apex fuscous. Wings slightly infuscate, veins darker.

Anal segment of male much broader than long, lateroapical angles decurved and produced in a stout spine. Pygofer with medioventral process broad, its lateroapical angles produced into short lobes, distally incurved, apical margin excavate with two minute eminences near middle. Aedeagus with phallobase four-lobed, as figured, two lobes simple, spinose, one with two spines and one with three and a blunt eminence; phallic appendages minutely denticulate over whole of distal surface. Genital styles bluntly ovate, a large three-toothed lobe dorsally near base.

One male **1,500 m., Shin-kai-sze, Omai Shan; Szechuan, W. China,** Aug. 16, 1940, Gressitt. This species is distinguished by coloration and by the shape of the male genitalia.

Genus **Plectoderoides** Matsumura

Matsumura, 1914:281. Orthotype, *Plectoderoides maculatus* Mats., 1914:282

Plectoderoides flavovittatus Fennah, new species.
(Figure 14, E–I.)

MALE: length, 2.8 mm.; tegmen, 3.5 mm. FEMALE: length, 3.0 mm.; tegmen, 4.8 mm.

Post-tibiae with a spine laterally near base, seven spines at apex. Basal metatarsal segment with seven spines at apex, second segment with six.

Yellow stramineous; a transverse bar on frons at base and at apex, a similar bar across clypeus, two bars on genae, disc of vertex on each side of median carina, pronotum with a stripe on each side of median carina, a stripe behind eyes, and another across lateral lobes, mesonotum, except laterally, a spot medioposteriorly on tegulae, bases of pro- and mesocoxae, two bands on each mesopleuron, dark reddish-brown. Tegmina translucent-fuscous, costal and subcostal cells to stigma, apical veins, cross veins and apical margin, inner half of clavus along the whole of its length, except for three or four spots on anterior claval vein, pale yellow, veins, apart from preceding, concolorous. Wings infuscate, veins darker.

Anal segment of male moderately short, apical margin excavate, lateroapical angles produced, bluntly rounded. Pygofer with lateral processes of each side broadly subtriangular, medioventral process long, distally laterally compressed. Phallobase with a pair of sinuate lobes dorsolaterally, that on left broader distally, unornamented, that on right narrower and more heavily sclerotised; a pair of lobes ventrolaterally, that on left subtriangular distally with ventral angle directed cephalad and with small spines at apex, that on right elongate, narrow, minutely denticulate on

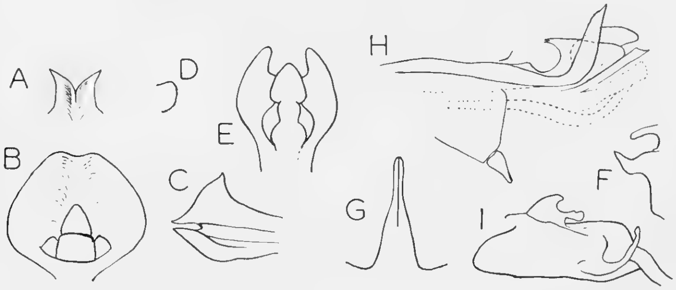


Fig. 14. *Magadha denticulata*, new species: A, medioventral process of pygofer; B, anal segment of male, dorsal view; C, apical portion of aedeagus, ventral view; D, denticulate process of left side of aedeagus near base. *Plectoderoides flavovittatus*, new species: E, anal segment of male, dorsal view; F, lateral process of pygofer; G, medioventral process of pygofer; H, aedeagus (ventral side uppermost); I, left genital style, inner aspect.

upper margin. Aedeageal processes long, ribbon-like, obliquely truncate and minutely serrate at apex.

Genital styles elongate-triangular, a long curved knobbed process on inner face near base, a broad curved three-cusped lobe at middle of dorsal margin.

Anal segment of female short. Pregenital sternite posteriorly transverse. Ovipositor with first valvulae four-spined, ventral lobe triangular, acute at apex; third valvulae broadly ovate, incurved distally. Bursa copulatrix armed at entrance with a triangular closely-grooved sclerite, supported on a slender wide crescentic base.

One male (the type) and one female, **Mokansan, Che Kiang Province, China,** Mrs. D. E. Wright, Sept. 1947. This species is distinguished by the shape of the genitalia and by coloration.

Plectoderoides uniformis Fennah, new species.

(Figure 15, F, G.)

Male: length, 2.9 mm.; tegmen, 4.2 mm. Female: length, 3.3 mm.; tegmen, 5.1 mm.

Post-tibiae laterally unispinose, seven-spined at apex.

Stramineous, head and mesonotum tinged with reddish-brown, abdomen dorsally fuscous. Tegmina sordid yellow, translucent, subapical and apical

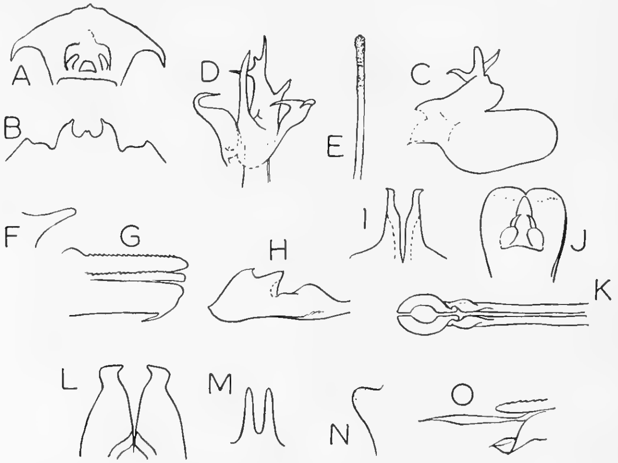


Fig. 15. *Magadha cervina*, new species: A, anal segment of male (lateral lobes spread out); B, medioventral portion of hind margin of pygofer; C, left genital style; D, aedeagus (phallobase); E, aedeagal (phallic) appendage. *Plectoderoides uniformis*, new species: F, lateral process of hind margin of pygofer; G, aedeagus, left side. *Caristianus ulysses* Fenn.: H, right genital style; I, medioventral process of pygofer; J, anal segment of male, dorsal view; K, aedeagus, dorsal view. *Akotropis fumata impersonata*, new subspecies: L, apical portion of anal segment, dorsal view; M, medioventral process of pygofer; N, dorsolateral lobe of hind margin of pygofer; O, apical portion of aedeagal processes, right side.

cells more or less completely infuscate, veins concolorous except marginal veinlets near stigma and transverse veins which are pallid. Wings lightly infuscate with darker veins.

Pygofer with laterodorsal angles narrow and finger-like. Phallobase with a pair of elongate lobes dorsolaterally, each serrate on upper and lower margins; mesad of, and slightly below these a pair of elongate unornamented lobes rounded-truncate at apex; a pair of broad smooth ventral lobes with ventral margins apposed, united distally and reflected ventrocephalad apically in a median spine; aedeageal lobes elongate, symmetrical, acuminate, apparently slightly more compressed laterally before apex. Genital styles of similar profile to those of *Caristianus*, a small blunt eminence on inner face near base.

One male, **Mokansan, Che Kiang Province, China,** Sept. 28, 1947, Mrs. D. E. Wright. One female, 1,000 m., Suisapa, Lichuan District, W. Hupeh, China, July 25, 1948, Gressitt is referred to this species. This species is distinguished by coloration.

Genus **Caristianus** Distant

Distant, 1916:63. Orthotype, *Caristianus indicus* Distant, 1916:63

Caristianus ulysses Fenn.
(Figure 15, H–K.)
Fennah, 1949:600.

MALE: length, 3.0 mm.; tegmen, 3.4 mm.

Post-tibiae laterally unispinose, eight-spined at apex, basal metatarsal segment seven-spined, second metatarsus with six spines.

Dark reddish-brown, carinae of vertex, except for two stripes laterally, lateral margins of frons, except for four stripes, a transverse band across apex of frons and base of clypeus, clypeus at apex, rostrum, discal carinae and ventral margin of lateral lobes, median carina of mesonotum, and lateral carinae suffusedly, legs and metapleurites stramineous. Tegmina dark reddish brown, an irregular spot in basal half of costal cell, distal half of costal cell, two areas in anterior half of subcostal cell, stigma, veinlets of R at margin, a spot at union of claval veins, and six other small spots on claval margin, cross-veins in Cu faintly, pallid ivory.

Anal segment of male about as long as broad, distal margin convex, notched at middle. Pygofer with each lateral margin produced near middle in a slender curved digitate process, medioventral process deeply bifid, each limb twisted and compressed near apex. Aedeagus narrowly tubular, shortly cleft medially at apex with a short horizontal lobe dorsally at apex on each side, forming a slight hood.

Genital styles subquadrate, sinuate on ventral and dorsal margins, with a simple triangular eminence near middle of dorsal margin.

One male, 6,500–7,500 ft., West Hills, Yunnan fu, Yunnan, S. China, Aug. 21–22, 1934, Ernest R. Tinkham. This is apparently the geographical representative of the Bornean species, known only from a single female: it differs from typical *C. ulysses* in the mesonotal disc being wholly dark, the pronotal disc narrowly infuscate between the carinae, and the lateral carinae of the frons transversely striped.

Genus **Akotropis** Matsumura

Matsumura, 1914:270. Logotype, *Akotropis fumata* Matsumura, 1914:270

Akotropis fumata impersonata Fennah, new subspecies.
(Figure 15, L–O.)

MALE: length, 2.9 mm.; tegmen, 3.3 mm. FEMALE: length, 2.8 mm.; tegmen, 3.5 mm.

Coloration as in typical subspecies, except for absence of any dark marking between eyes and lateral carinae of frons. Genitalia as figured. Posttibiae laterally unispinose, distally 8-spined. Basal metatarsal segment seven-spined, second metatarsal six-spined.

One male (the subspecific type) and 5 females, **Mokansan, Che Kiang Province, China,** Aug. 4–Sept. 28, 1927, Mrs. D. E. Wright; one male and two females, 1,000 m. Suisapa, Lichuan District, W. Hupeh, China, Aug. 19, 1948, Gressitt. In the specimens from Suisapa the ground color of the tegmina is distinctly darker than in the Mokansan series.

Akotropis flaveola Mats.
Matsumura, 1914:271.

One female, Rivière de Quangtri, Anam, April 30, 1927, Mrs. D. E. Wright, is tentatively referred to this species. There is a slight curved fuscous stripe in the region of the ocelli.

Genus **Zathauma** Fennah

Fennah, 1949:605. Orthotype, *Zathauma cristatum* Fennah, *loc. cit.*

Zathauma metasequoiae Fennah, new species.

FEMALE: length, 5.8 mm.; tegmen, 8.0 mm.

Vertex broader across base than long in middle line (3:1), posteromedial portion of disc declivous, remainder hollowed out; frons in middle line longer than greatest width (1.8:1), and longer than clypeus in middle line (1.3:1), greatest width of frons 1.7 times width at base; rostrum with apical segment 1.6 times as long as subapical, attaining post-trochanters. Pronotum with disc twice as broad across base as long in middle line, longer in middle line than vertex in same line (1.7:1) depressions laterad of disc very feeble; two carinae on each side between eye and tegula; mesonotum tricarinate, carinae prominent except on scutellar area, which is medially ecarinate, lateral carinae diverging from apex to base, anterior portion of mesonotum of different texture from posterior; tegulae large, not carinate; protibiae slightly exceeding profemora, post-tibiae with a spine at basal third, six small spines and one large spine at apex, basal metatarsal segment with 6 teeth, the outermost largest, second metatarsal segment with two large outer teeth and a row of four short teeth between them; post-coxae produced lateroposteriorly in a short spine.

Basal half of clypeus, sides of head below antennae, all femora at apex, all tibiae at base and apex creamy yellow, frons except for a few pale fuscous spots at margins distally, vertex, pronotum, except lateral lobes, anterior part of mesonotal disc, mesonotum laterally, and tegulae, testaceous-stramineous; distal part of clypeus, rostrum, lower side of thorax, posterior part of mesonotal disc, legs, and abdomen dark fuscous. Tegmina creamy-white at extreme base, elsewhere fuscous-piceous sparingly marbled with grey, veins concolorous with small pallid spots, and pallid apex at margin, transverse veins mostly pallid, pallor most pronounced in first branch of Sc at node; wings smoky.

Pregenital sternite large, fully as long as fifth and sixth ventrites combined, hind margin shallowly convex. Subvaginal plate about as long as broad, its sides concave, mesal margins of ventrolateral parts of eighth segment with a submarginal channel basally; posterior angle subrectangulate.

One female, from *Metasequoia glyptostroboides*, **1,000 m., Suisapa, Lichuan District, W. Hupeh,** Aug. 21, 1948, Gressitt. This species is larger than the type, has a differently-shaped vertex and lacks the foliately raised mesonotal carina. The cephalic differences, however, are no greater than those in *Faventilla,* and in other characters, including tegminal venation and coloring, it generally resembles *Z. cristatum.*

Genus **Betatropis** Matsumura

Matsumura, 1914:274. Orthotype, *Betatropis formosana* Matsumura

Betatropis formosana Matsumura.

Matsumura, 1914:274.

Eight males and 10 females, Mokansan, Che-Kiang Province, China, Aug. 26–Sept. 24, 1927, Mrs. D. E. Wright.

Genus **Tangina** Melichar

Melichar, 1903:223. Haplotype, *Tangina bipunctata* Melichar, 1903:44

KEY TO SPECIES OF TANGINA

(1) (2) Vertex with two black or infuscate spots at apex .... (3)
(2) (1) Vertex without such spots .... (5)
(3) (4) Tegmina translucent, pallid yellow. Luzon .... *T. quadripunctata* Mel.†

(4) (3) Tegmina pale yellow with two oblique dark stripes at apex of costal cell, and a black spot in first apical cell of Sc, which is bounded by black veins. Ceylon .... *T. bipunctata* Mel.

(5) (6) Tegmina pale, a longitudinal stripe on Sc + R and another along sutural margin black, membrane infumed; a black spot on propleura. Luzon........ *T. quadrilineata* Mel.

(6) (5) Tegmina tinged fuscous, a broad band along anterior margin white, a dark spot in first and second infumed apical cells; a black spot on mesopleura. China........ *T. sinensis*, new species

---

† *T. modesta* Haupt is probably not a member of this genus. It is distinguished from *T. quadripunctata* by the absence of two piceous spots on the pronotum and its generally darker hue.

Tangina sinensis Fennah, new species.

MALE: length, 2.5 mm.; tegmen, 3.0 mm. FEMALE: length, 2.8 mm.; tegmen, 3.4 mm.

Post-tibiae 8-toothed at apex; basal metatarsal segment 6-toothed distally, second metatarsal segment 5-toothed.

Creamy-white; a large round spot on mesopleura piceous; mesonotum tinged yellow, distal half of abdomen dorsally and ventrally orange-yellow. Tegmina translucent, pale fuscous, a band of even width along costal margin to beyond stigma, extending inward to middle of cell Sc + R, white; a minute spot in first infuscate apical areole beyond stigma and a larger round spot in adjoining apical areole, piceous. Wings hyaline, powdered white.

Pygofer with medioventral process deeply cleft medially. Genital styles triangular in profile, a triangular spinose process at middle of dorsal margin, directed laterad, and a similar process at apex directed dorsocephalad. Phallobase relatively long, with a pair of narrow tapering lobes dorsally, decurved at apex, minutely denticulate on ventrolateral margin, medioventrally a long straight spine directed cephalad.

Pregenital sternite of female posteriorly shallowly convex.

One male and 1 female, **Mokansan, Che-Kiang Province, China,** Sept. 2, 19, 1927, Mrs. D. E. Wright. This species differs from *T. bipunctata* in the absence of piceous marks on the head, of fuscous lateral mesonotal fields, and in the general infuscation of the tegmina coupled with the absence of oblique dark lines near the stigma.

Family **DICTYOPHARIDAE** Spinola

KEY TO GENERA OF CHINESE DICTYOPHARIDAE

(1) (2) Femora and tibiae, or merely lower angle of femora more or less widened into a flange........ (3)

(2) (1) Femora and tibiae not at all widened........ (7)

(3) (4) Vertex fully as long as pronotum and mesonotum combined; profemora with a small tooth subapically; post-tibiae with 5 spines........ (5)

(4) (3) Vertex not nearly as long as pronotum and mesonotum combined. Post-femora unarmed; post-tibiae 6–7 spined .... *Orthopagus* Uhl.
(5) (6) Cephalic process with two slight constructions, its apex bombinate .... *Piela* Lall.
(6) (5) Cephalic process not constricted nor apically bulbous .... *Saigona* Mats.
(7) (8) Vertex with cephalic process more than three times as long as broad .... (9)
(8) (7) Vertex not more than three times as long as broad .... (13)
(9) (10) Head much narrower than pronotum; cephalic process slender, scarcely widened at apex, porrect. Post-tibiae with four spines .... *Thanatodictya* Kirk.
(10) (9) Head not greatly narrower than pronotum, cephalic process relatively stout .... (11)
(11) (12) Cephalic process with lateral margins feebly defined, transversely and irregularly rugose on upper surface. Post-tibiae 1-spined .... *Leprota* Mel.
(12) (11) Cephalic process with lateral margins strongly carinate, median carina present only near base, upper surface slightly concave longitudinally. Post-tibiae 4–5 spined .... *Chanithus* Kol.
(13) (14) Vertex narrow throughout, 2.5–3 times as long as broad, its lateral margins sinuate .... (15)
(14) (13) Vertex not narrow throughout, relatively broad between eyes, not more than twice as long as broad .... (17)
(15) (16) Lateral carinae of frons widest apart between eyes .... *Togaphora* Mats.
(16) (15) Lateral carinae of frons widest apart near fronto-clypeal suture .... *Avephora* Bierm.
(17) (18) Carinae of pronotal disc strongly developed .... *Tropidophara* Bierm.
(18) (17) Carinae of pronotal disc almost obsolete .... *Sinodictya* Mats.

No Chinese species are known to the writer which fall into the restricted concept of *Dictyophara* Germar (Fennah, 1944: 81, 82, 90).

Genus **Orthopagus** Uhler

Uhler, 1896:278. Haplotype, *Orthopagus lunulifer* Uhler

Orthopagus helios Melichar.

Melichar, 1912:60.

Two males, Mokansan, Che Kiang Province, China, (Mrs. D. E. Wright, Sept. 8, 1927) agree with the description of *O. helios* Mel.; 1 female, Taihanroku, agrees exactly with the description of *O. elegans* Mel.; 1 male and 1 female, Taihanroku, Japan (H. Salter, July 22, 1908), agree exactly with the description of *O. helios* var. *diffusus* Mel., which was described from Taihanroku material. The proportions of the vertex (length : breadth) in the above material is 1.7 : 1. Even with the present short series there seems little room for doubt that all the above material is conspecific.

One male, Nai-suen, 21 m. S. E. of Naam-fung, Lin Kao District, Hainan Island, S. China (Aug. 31, 1932) differs from the preceding in having the vertex not more than 1.6 times as long as broad and the lateral margins of the frons relatively straight. This may prove to be specifically distinct from the preceding, but the constriction at the middle of the vertex and the proportion of the produced relative to the basal portion debar it from being placed in the *splendens–fletcheri* section of Melichar's key.

Genus **Chanithus** Kolenati

Kolenati, 1857:427. Haplotype, *Flata pannonica* Germar, 1830:47

Chanithus gramineus (F.).
Fulgora graminea Fabricius, 1803:4.
Dictyophora sinica Walker, 1851:321.

Eight males, 7 females, Mokansan, Che-Kiang Province, 24, Sept. 6, 1927, Mrs. D. E. Wright; 3 males, 2 females, Lau-Chi, Che Kiang Province, July 9, 12, Mrs. D. E. Wright; 2 males, 1 female, Tunglu, Che Kiang Province, Sept. 8, 10, 1926, Mrs. D. E. Wright; 2 males and 2 females, 800–1,000 ft., Chang Tau Ching, Szechwan, July 18, 1948, Gressitt; 3 females, 1,000 m., Suisapa, Lichuan District, W. Hupeh, Aug. 19, 20, 25, 1948, Gressitt.

The intensity of pigmentation is slightly variable, but no geographical subspecies can be recognized in the above series.

Genus **Tropidophara** Bierman

Bierman, 1910:15. Haplotype, *Tropidophara dubiata* Bierman, 1910:16

Tropidophara javana (Lethierry).
Dictyophara javana Lethierry, 1888:467.

One male, between Limchow and Kung-kon, Hoh-p'u District, Kwangtung, S. China, Aug. 5, 1932, W. E. Hoffman.

Genus **Thanatodictya** Kirkaldy

Kirkaldy, 1906:392. Haplotype, *Dictyophara praeferrata* Distant, 1892:279

Thanatodictya lineata (Donovan).
Fulgora lineata Donovan, 1800:1, pl. 8, fig. 1.

One female, Tin T'au Village, Lam Lo District, Hunan Province, S. China, July 29, 1934.

Genus **Avephora** Bierman

Bierman, 1910:12. Haplotype, *Avephora pasteuriana* Bierm., 1910:12

Avephora eugeniae (Stål).
Pseudophana eugeniae Stål, 1859:271.
Avephora pasteuriana Bierman, 1910:12.

One male, Tai Kwong village, Lam Ho District, Hunan Province, S. China, July 26–28, 1934; 1 male, Hokcow (near Leokay, Tonkin), Yunnan,

S. China, Aug. 16, 1934, Chauncey Brownall; 1 female, White Cloud Mountain, Canton, China, July 6, 1932.

Family **FULGORIDAE** Latreille

KEY TO GENERA OF CHINESE FULGORIDAE

(1) (2) Cephalic process porrect, stout and distally rounded, much longer than pronotum and mesonotum together........*Pyrops* Spin.

(2) (1) Cephalic process much shorter than pronotum, or with a slender appendage........(3)

(3) (4) Cephalic process, at least at base, strongly recurved dorsad and overlying apical margin of vertex........(5)

(4) (3) Cephalic process very short, directed dorsad, with a small shallow depression at apex to which a slender rod-like appendage is weakly attached; anterior femora ampliate near apex........*Kalidasa* Kirk.

(5) (6) Carinae of frontal disc weak, near base separated almost by twice width of eye, converging strongly distad........*Penthicodes* Blanch.

(6) (5) Carinae of frontal disc subparallel, obsolete in distal third....*Lycorma* Stål

Genus **Lycorma** Stål

Stål, 1863:232. Logotype, *Aphana imperialis* White, 1846:330

Lycorma delicatula (White).
Aphaena delicatula White, 1845:37.

Post-tibiae laterally 5-spined, apically 7-spined.

Three males and 2 females, 1,000 m., Suisapa, Lichuan District, W. Hupeh, China, Aug. 21, 1948, Gressitt.

Family **TROPIDUCHIDAE** Stål

KEY TO GENERA OF CHINESE AND FORMOSAN TROPIDUCHIDAE

(1) (2) Tegmina leathery, brown, with numerous and irregular cross veins; if subhyaline distally, distal area not demarcated basally by a distinct line of transverse veinlets........(3)

(2) (1) Tegmina hyaline; if of a denser consistency then cross-veins relatively few and regular, or membrane abruptly and very closely reticulate....(5)

(3) (4) Tegmina with Cu_1 forked just distad of union of claval veins; wings reduced........*Padanda* Dist.

(4) (3) Tegmina with Cu_1 not forked as described. Wings normal....*Olontheus* Jac.

(5) (6) Tegmina with not more than nine cells at apical margin........(7)

(6) (5) Tegmina with more than nine apical cells........(15)

(7) (8) Frons setose. Longest apical cell in tegmina longer than clavus........*Trichoduchus* Bierm.

(8) (7) Frons not setose. Longest apical cell relatively shorter........(9)

(9) (10) Frons unicarinate. Tegmina with a single row of transverse veinlets........*Ommatissus* Fieb.

(10) (9) Frons tricarinate. Tegmina with two rows of transverse veinlets, or transverse veinlets few......(11)

(11) (12) Tegmina with nodal line straight, distinct, with one row of transverse veins distad of it......*Zema*, new genus

(12) (11) Tegmina with nodal line not demarcated, transverse veins rather irregular, straight or oblique......(13)

(13) (14) Sc + R and Cu_1 simple in basal half of tegmina......*Cixiopsis* Mats.

(14) (13) Sc + R and Cu_1 forked in basal half of tegmina......*Duriopsis* Mel.

(15) (16) Tegmina with pre-costal area traversed by distinct veinlets......(17)

(16) (15) Tegmina with costal vein at margin, or if submarginal, then without distinct transverse veinlets......(23)

(17) (18) Tegmina with venation of distal third irregular, densely reticulate......*Mesepora* Mats.

(18) (17) Tegmina with venation of membrane not as above......(19)

(19) (20) Tegmina with Cu_1 forked basad of level of union of claval veins; nodal line situated two-thirds of length of tegmen from base......(21)

(20) (19) Tegmina with Cu_1 forked distad of union of claval veins; nodal line only slightly distad of middle of tegmen......*Eodryas* Kirk.

(21) (22) Second antennal segment cylindrical, more than twice as long as first......*Catullia* Stål

(22) (21) Second antennal segment short, not as above......*Epora* Wlk.

(23) (24) Tegmina basad of nodal line of cross-veins distinctly thicker than in apical portion......(25)

(24) (23) Tegmina of uniform consistency throughout......(29)

(25) (26) Vertex longer than pronotum and mesonotum together, sides of head distinctly constricted just before eyes......*Ossoides* Bierm.

(26) (25) Vertex not so produced......(27)

(27) (28) Frons weakly ampliate distally, lateral margins and median carina normal; lateral carinae of pronotal disc almost parallel with sides of vertex......*Tambinia* Stål

(28) (27) Frons strongly ampliate to below level of antennae, lateral margins and median carina at base thickened, lateral carinae of pronotal disc curving outward toward tegulae......*Kallitaxila* Kirk.

(29) (30) Vertex approximately twice as long as broad in middle......(31)

(30) (29) Vertex relatively shorter, not or scarcely longer than broad......(33)

(31) (32) Tegmina with Sc + R forked once shortly before nodal transverse line, M and Cu_1 simple......*Tauropola* Jac.

(32) (31) Tegmina with Sc + R three-branched at nodal line, Cu_1 forked near level of union of claval veins......*Swezeyaria* Metc.

(33) (34) Vertex anteriorly transverse; pronotal disc large; tegmina long with nodal line slightly basad of middle; Cu_1 forked before nodal line......*Sogana* Mats.

(34) (33) Vertex anteriorly convex or acute; pronotal disc small; tegmina with nodal line not basad of middle; Cu_1 simple basad of nodal line......*Neommatissus* Muir

In the above synopsis, Chinese species which have been referred to *Kallitambinia* Muir will run to *Tambinia* Stål, where they may well be placed until the limits of the former genus have been more precisely defined: Muir's concept, as interpreted from the type species, is restricted to forms with trispinose post-tibiae and claval veins which unite distad of the middle of the clavus. In *Tambinia* the post-tibiae are normally bispinose and the claval veins unite basad of the middle of the clavus.

Nacmusius Jac. (1944: 19) runs to *Padanda* Dist., and the writer can trace no generic character in which they differ. (It may be noted parenthetically that the holotype of the African *Padanda denti* Muir is an issid.) Notwithstanding its hiraciine appearance, the writer suspects that *Padanda* is related to a group of genera near *Ommatissus* Fieb. and including *Cixiopsis* Mats., *Duriopsis* Mel. (assigned by its author to Issidae), and a new genus described below. Perhaps *Olontheus* is likewise related to this group.

Parahiracia Ôuchi (1940: 299), which was described as a hiraciine tropiduchid, is here considered to belong to the Issidae.

Genus **Catullia** Stål

Stål, 1870:748. Haplotype, *Catullia subtestacea* Stål.

Catullia subtestacea Stål.

Stål, 1870:749.

One male, Cheung-nga San, Tin-tong, Loh-chang District, Kwangtung, Sept. 9, 1947; 1 female, Tai-ka, Tin-tong, Loh-Chang District, Aug. 20, 1947; 1 female, Naam-kong-paai, Yao shan, Yang-shan District, Kwangtung, Oct. 29–30, 1934; 1 male, Tai Kwong village, Lam Mo District, Hunan Province, S. China, July 26–28, 1934; 1 male, Kwei-Hsien, Kwei-Hsien District, Kwangsi, S. China, July 28–29, 1934, E. R. Tinkham; 2 males and 2 females, Mokansan, Che-Kiang Province, Sept. 2, 6, 22, 1927, Mrs. D. E. Wright.

Genus **Kallitaxila** Kirkaldy

Kirkaldy, 1901:6. Orthotype, *Kallitaxila granulata* Stål

Kallitaxila granulata Stål.

[*Taxila*] *granulata* Stål, 1870:750.

One female, Honam Island, P'an-yu District, Canton, June, 1935, W. E. Hoffman.

Genus **Sogana** Matsumura

Matsumura, 1914:268. Haplotype, *Sogana hopponis* Mats.

Sogana hopponis Matsumura

Matsumura, 1914:268.

One female, 800 m., Hori (Pull. Polisia), Taichung District, Formosa, Aug. 23, 1947, L. Gressitt.

Genus **Ossoides** Bierman

Bierman, 1910:26. Haplotype, *Ossoides lineatus* Bierman

Ossoides lineatus Bierman.
Bierman, 1910:27.

One female, White Cloud Mountain, P'an-yu District, Canton, Dec. 16, 1934.

Genus **Neommatissus** Muir

Muir, 1913:267. Orthotype, *Neommatissus spurcus* Muir

Neommatissus congruus (Walker)
Brixia congrua Walker, 1870:110.
Neommatissus spurcus Muir, 1913:268.

One female, Sao-tio, Tin-tong, Loh-chang District, Kwangtung, Aug. 23, 1947.

Genus **Eodryas** Kirkaldy

Kirkaldy, 1907:93. Haplotype, *Epora subtilis* Mel. not Walk. 1903:
=*E. melichari* (Dist.)

Eodryas melichari Distant.
Gen. ? *melichari* Distant, 1906:285.

One female, Honam Island, Canton, July 12–14, 1932; 1 female, Taipingfu, Sung-shen District, Kwangsi, Aug. 5–6, 1934, E. R. Tinkham.

Genus **Ommatissus** Fieber

Fieber, 1875:353. Haplotype, *Ommatissus binotatus* Fieb., 1876:174.

Ommatissus lofouensis Muir.
Muir, 1913:267.

Post-tibiae laterally bispinose, apically 8-toothed. Basal metatarsal segment 7-toothed.

Aedeagus longer than post-femora, comprising a pair of long, slender ribbon-like processes directed caudad, acuminate at apex, and an even longer median cylindrical process gradually decurved distad but curved upward at distal fifth to point dorsad, apex not acuminate. Genital styles elongate-triangular, bluntly rounded distally, a small spine, curved laterad dorsally near base.

One male, Mokansan, Che Kiang Province, Aug., 1927, Mrs. D. E. Wright. There is no doubt that this species is congeneric with *O. binotatus* Fieb.

Zema Fennah, new genus

Vertex about twice as broad as long, anterior margin obtusely angulately convex, posterior margin correspondingly rounded-concave, lateral margins slightly converging distad, median carina present only in basal two-thirds, an impression at each side on disc; frons in middle line longer than greatest width (1.3: 1), basal margin transverse, lateral margins diverging to below level of antennae, thence shallowly incurved; a transverse callus across frons at base, with median and two lateral discal carinae arising from it, the latter enclosing an oval which is widest about level of lower margin of eyes; clypeus about two-thirds as long as frons, not distinctly carinate but with median area raised. Pronotum in middle line rather longer than vertex in same line, anterior margin rounded convex, posterior margin subangulately concave with a distinct notch at middle; disc tricarinate, an impression on each side of middle line, lateral carinae diverging caudad, anteriorly evenly curving mesad into anterior margin, a single carina on each side between eye and tegula; mesonotum broader than long, median carina reaching to scutellum, which is not divided from disc by a groove, lateral carinae evenly curved mesad anteriorly. Post-tibiae with four spines laterally, and eight small spines at apex; basal metatarsal segment with about nine teeth at apex, second metatarsal segment short, with a spine at each apical angle and a convex pad between them.

Tegmina about three times as long as broad, widest at level of nodal line, costal margin and sutural margin subparallel, the former only weakly incurved at base. Sc + R, M, and Cu united to level of nodal line, distad of nodal line a single distinct row of transverse veins; claval suture present, flexible, claval veins united at middle of clavus. Wings ample, Sc + R, M, and Cu_1 each forked once.

Ovipositor with first valvulae denticulate on ventral margin with two blunt teeth at apex, a single relatively large tooth at apex, and two blunt teeth on dorsal margin; third valvulae with two or three teeth on dorsal margin and about five teeth on apical margin.

Type species, *Zema gressitti,* new species.

The present concept is separated from *Cixiopsis* by the shape of the frons and the tegminal venation: in *Cixiopsis* the frons is narrowed in the middle, and the lateral discal carinae unite with the median carina in a point; the lateral carinae are foliate, as is visible from above, and the clypeus is medially carinate. In the tegmina the claval veins unite two thirds from the base of the clavus, and there is a network of veinlets on the distal third. From *Ommatissus* it is separated, in addition to other characters, by the carination of the frons and by the shape and venation of the tegmina: in *Ommatissus* the disc of the frons is unicarinate, while the tegmina are more acutely curved at the apical margin; moreover Cu_1 forks on the corium near the union of the claval veins. It differs from *Padanda* in the shape of the head and pronotum and in tegminal venation: in *Padanda* the frons is less narrowed basally and the lateral discal carinae begin their mesad curvature rather nearer the base: in the tegmina of Distant's holotype Sc + R and M are simple on the corium, but Cu_1 is forked slightly distad of the union of the claval veins; moreover numerous irregular transverse veinlets are present and form a lax reticulum. The type of *P. atkinsoni* is relatively short-winged: the claval suture is evident, but is not a functional line of flexure: the wings are extremely reduced.

Zema gressitti Fennah, new species.
(Figure 16, A–F.)

Female: length, 5.0 mm.; tegmen, 4.9 mm.

Vertex anteriorly broadly rounded. Tegmina with claval suture present and functional; venation regular; wings fully developed.

Testaceous to dark tawny: intercarinal area of vertex, a spot overlying each impression on pronotal disc, dorsal portion of lateral lobes of pronotum, mesonotum except laterally, middle of clypeus, tip of rostrum, thoracic pleurites and abdominal sclerites fuscous-piceous; a broad band overlying fronto-clypeal suture, extending across sides of head, stramineous, ventral portion of lateral lobes of pronotum, ivory-white; most of frontal disc, stripes along all femora and tibiae, pro- and mesotarsi fuscous. Third valvulae of ovipositor piceous dorsally, translucent testaceous ventrally.

One female, **Lung-chi-pa, Szechuan-Hupeh border,** July 19, 1948, Gressitt.

Family **ISSIDAE** Spinola

KEY TO GENERA OF CHINESE ISSIDAE

(1) (2) Tegmina usually brachypterous. Basal metatarsal segment with two spines .... (3)
(2) (1) Tegmina macropterous, covering abdomen completely. Basal metatarsal segment with more than two spines .... (7)
(3) (4) Profemora and protibiae foliate in male, compressed and weakly foliate in female .... *Caliscelis* Lap.

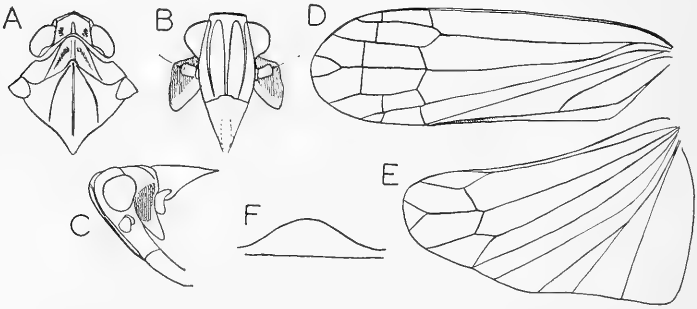


Fig. 16. *Zema gressitti*, new genus and species: A, head and thorax; B, frons and clypeus; C, head and thorax, side view; D, tegmen; E, wing; F, pregenital sternite of female.

(4) (3) Legs normal, or only protibiae widened distally at external angles......(5)

(5) (6) Second segment of antennae transverse at apex with arista inserted apically and projecting in same line as axis of second segment...... *Ommatidiotus* Spin.

(6) (5) Second segment of antennae lateroapically produced in a distinct hump; arista projecting almost at right angle to axis of second segment...... *Conocaliscelis* Mats.

(7) (8) Body-form hemispherical. Tegmina strongly curved, claval suture absent ......(9)

(8) (7) Not as above ......(15)

(9) (10) Wings well developed......(11)

(10) (9) Wings rudimentary ......*Hemisphaerius* Schaum

(11) (12) Frons narrow, median carina present......*Darumara* Merc.

(12) (11) Frons broad, median carina absent......(13)

(13) (14) Anterior margin of vertex not carinate; lateral margins of frons straight, divergent distally as far as subangulate inflexure below level of antennae ......*Gergithus* Stål

(14) (13) Anterior margin of vertex carinate; lateral margins of frons roundly diverging to below level of antennae thence smoothly incurved, outline convex, not subangulate ......*Mongoliana* Dist.

(15) (16) Frons in profile strongly produced, anterior margin of vertex basad of level of anterior margin of eyes......(17)

(16) (15) Frons in profile straight or shallowly convex; anterior margin of vertex distad of anterior margin of eyes......(21)

(17) (18) Basal area of frons tricarinate. Protibiae and mesotibiae not foliately expanded ......*Fortunia* Dist.

(18) (17) Basal area of frons with two carinae which unite basally. At least protibiae subfoliately expanded ......(19)

(19) (20) Mesotibiae foliately expanded......*Parahiracia* Ôuchi

(20) (19) Mesotibiae not foliately expanded......*Clipeopsilus* Jac.

(21) (22) Vertex twice as broad as long in middle, or nearly so, frons at least as broad as long. Wings trilobed......(23)

(22) (21) Vertex not twice as broad as long, or if so then frons longer than broad. Wings with margin indented only once......(31)

(23) (24) Vertex more than three times as broad as long in middle; frons with lateral carinae parallel to below level of antennae. Wings absent...... *Hysteropterum* A. & S.

(24) (23) Vertex not three times as broad as long......(25)

(25) (26) Frons with a carina completely across base parallel to anterior margin of vertex; median carina distinct as far as fronto-clypeal suture, sublateral carinae developed only at laterobasal angles......*Gelastyra* Kirk.

(26) (25) Frons without a complete transverse carina across base in addition to carina between frons and vertex......(27)

(27) (28) Tegmina broadest at level of claval apex. Wings with margin only shallowly indented, both postcubital and anal lobes narrow and small in relation to anterior lobe......*Kodaianella*, new genus

(28) (27) Tegmina broadest in basal half; wings with postcubital and anal lobes ample .... (29)

(29) (30) Wings with posterior vein of anterior lobe and anterior vein of postcubital lobe fused into a single thick stem lying in groove near apical margin .... *Sarima* Mel.

(30) (29) Wings with these veins separate, linked only at apical margin by a very short oblique sclerotized strut........ *Tetrica* Stål

(31) (32) Frons tricarinate; vertex with anterior margin strongly convex. Tegmina devoid of claval suture .... *Neodurium*, new genus

(32) (31) Frons not carinate or only weakly medially so at base........ (33)

(33) (34) Lateral margins of vertex and frons laminate. Tegmina with Sc + R united in a common stalk on basal quarter; wings with Sc + R forked at middle .... *Tetricodes*, new genus

(34) (33) Lateral margins of vertex and frons acute but not foliate. Tegmina with Sc and R separate from base; wings with Sc + R not forked .... *Duriopsilla*, new genus

The above synopsis has been compiled in part from literature, and obvious differences in published characters have been used for the separation of genera. The result does not represent a full evaluation of the genera here listed. *Parahiracia* Ôuchi and *Clipeopsilus* Jac. may well be congeneric and both may ultimately be suppressed under *Fortunia* Dist. The whole Hemisphaeriinae require critical study. The rather large number of monotypic genera of Issidae described in the Fauna of British India (Distant, 1906, 1916), which is increased in the present report, probably reflects a paucity of specimens rather than incorrect delimitation of generic concepts, but a study of further material from eastern Asia is much to be desired.

Genus **Mongoliana** Distant

Distant, 1909:87. Haplotype, *Hemisphaerius chilochorides* Wlk.

Mongoliana chilochorides (Wlk.).

Hemisphaerius chilochorides Walker, 1851:379.

Eight males and 9 females, Okinawa, April, 1912, J. C. Thompson; 1 female, Chizuka, Okinawa, July–Sept., 1945, Bohart and Harnage, 1945; 1 male and 2 females, Mimasaka, Japan, July, 1912, J. C. Thompson.

Mongoliana recurrens (Butl.).

(Figure 17, G, H; Figure 18, A–C; Figure 19, B.)

Hemisphaerius recurrens Butler, 1875:98, pl. 4, fig. 20.

Frons longer than broad (1.1: 1), medially ecarinate. Tegmina almost smooth, with dull polish, wings distinctly shorter than tegmina. Post-tibiae 2-spined at sides, 7-spined at apex, basal metatarsal segment with two stout spines and seven small intervening spines.

Sepia brown; a transverse bar across clypeus at base, a similar bar across frons at apex, round mottling on frons and sides of head, eleven round spots along a shallow sulcus near each lateral margin of frons, anterior and lateral carinae of vertex (in part), a series of small spots along anterior margin of pronotum and a small round spot on disc on each side of middle, lateral carinae of mesonotal disc and scutellum, ivory yellow. Clypeus, distal portions of lateral lobes of pronotum, pro- and mesocoxae, pro- and mesofemora, pro- and mesotibiae in basal two-thirds piceous; pro- and mesotrochanters, rostrum, hind legs and lower surface of abdomen testaceous. Tegmina uniformly very dark castaneous, a short transverse linear spot inward from sutural margin at level of apex of clavus.

Anal segment short, broad, expanding distally, widest at truncate apical margin, anal foramen in distal half, lateroapical angles rounded. Pygofer with lateral margins convex. Aedeagus shallowly U-shaped, phallobase terminated dorsally in a pair of short tapering bluntly-pointed lobes, ventrally in a pair of short, broad, rounded lobes, laterally deeply incised, more so on left than right. Aedeagus with a pair of long curved blade-like spines arising ventrolaterally distad of middle, directed cephalad and slightly dorsad near apex, apex of aedeagus broadly bilobate, each lobe obliquely truncate. Genital styles moderately narrow at base, expanding distally, apical margin more or less semicircularly curved, dorsal margin in middle produced dorsad in an oblique, transversely-compressed biscuspidate process.

Posterior margin of pregenital sternite broadly and shallowly subtriangularly produced at middle.

One female, Lung-Tau Shan, N. Kwangtung, June 11, 1947, Gressitt; one male and 1 female, 1,000 m., Suisapa, Lichuan District, W. Hupeh, June 23, 1948, Gressitt.

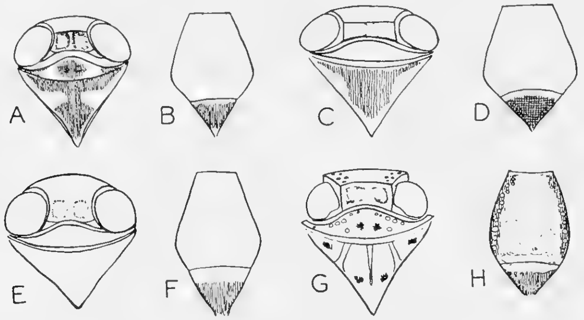


Fig. 17. *Hemisphaerius rufovarius* Wlk.: A, head and thorax; B, frons and clypeus. *Hemisphaerius imitatus* Mel.: C, head and thorax; D, frons and clypeus. *Gergithus iguchii* Mats.: E, head and thorax; F, frons and clypeus. *Mongoliana recurrens* Butl.: G, head and thorax; H, frons and clypeus.

Genus **Gergithus** Stål

Stål, 1870:756. Type, *Hemisphaerius schaumi* Stål, 1855:191

Gergithus rugulosus Melichar.
Melichar, 1906:64.

One male, Hong Kong, China, Koebele, Oct. 1895.

Gergithus iguchii Mats.
(Figure 17, E, F; Figure 19, A.)
Gergithus iguchii Matsumura, 1916:98.

Female: length, 3.5 mm.; tegmen, 4.8 mm.

Frons slightly convex, smooth, ecarinate, polished. Post-tibiae 2-spined laterally, 6-spined at apex, basal hind tarsus with a spine at each angle, and 7 spines between. Tegmina with veins prominent, sub-parallel, with a few cross-veins or anastomoses.

Castaneous-fuscous; a band across base of clypeus, extending on genae up to antennae, and pro- and mesocoxae at base, pallid yellow; clypeus, femora at base and tibiae laterally (except on hind legs), piceous; mesonotum golden yellow. Tegmina golden yellow, costal margin broadly at base, narrowly distally, apical margin broadly, three large contiguous spots lying across basal third, two larger contiguous spots lying across apical third castaneous-fuscous. Wings pallid grey with darker veins.

Twelve females, Mokansan, Che Kiang Province, China. It is possible

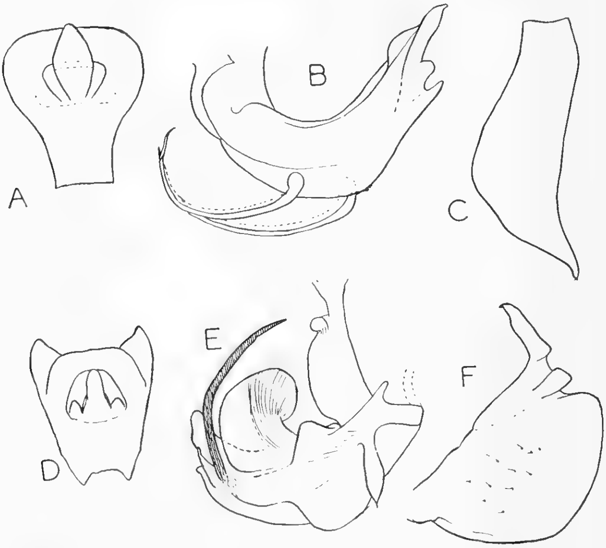


Fig. 18. *Mongoliana recurrens* Butl.: A, anal segment of male; B, aedeagus, left side; C, pygofer, left side. *Hemisphaerius signifer* Wlk.: D, anal segment of male; E, aedeagus, right side; F, left genital style.

that the Che Kiang population is subspecifically distinct, as the darker markings are relatively larger, but the point cannot be settled with material of one sex only. The anterior carina of the vertex is obsolete, and this species could perhaps be referred to *Hemisphaeroides* Mel., but the latter genus requires re-defining before further species can be assigned to it with confidence.

Genus **Hemisphaerius** Schaum

Schaum, 1850:71. Haplotype, *Issus coccinelloides* Burm., 1833:305

Hemisphaerius rufovarius Wlk.
(Figure 17, A, B.)
Walker, 1858:95.

The present material differs from Walker's type only in the presence of two obscure small piceous spots in the apical third of the tegmina.

One male, Dwa Bi, Hainan Island, July 25, 1935, Gressitt, and 1 mutilated specimen, Ta Han, Hainan Island, June 24, 1935, Gressitt.

Hemisphaerius imitatus Melichar.
(Figure 17, C, D).
Melichar, 1906:88.

Female: length, 4.4 mm.; tegmen, 4.2 mm.

Greenish translucent. Clypeus, except for a yellow transverse band at base, a spot on each lateral lobe of pronotum at ventral margin, pro- and mesocoxae, two transverse bands on pro- and mesotibiae, post-femora except at apex, and both surfaces of abdomen piceous, with hind margin of each segment bordered yellow.

One female, 2,000 ft., Kepakiang, Sumatra (H. C. Kellers), presented by W. M. Giffard.

Hemisphaerius signifer Walker.
(Figure 20, A–C; Figure 18, D–F.)
Walker, 1851:380.

One male, 1,000 m., Suisapa, Lichuan District, W. Hupeh, China, Aug. 19, 1948, Gressitt.

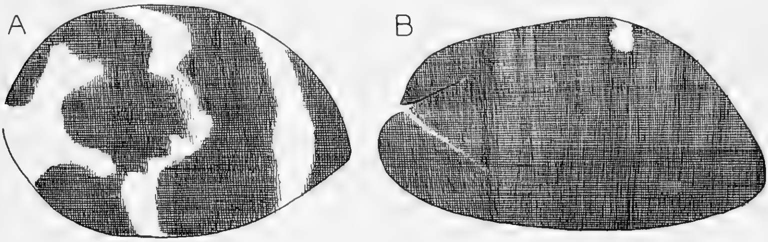


Fig. 19. *Gergithus iguchii* Mats.: A, tegmen. *Mongoliana recurrens* (Butl.): B, tegmen.

Kodaianella, Fennah, new genus

Frons broader than long in middle line (1.6 : 1), lateral margins diverging straight to below level of antennae, thence abruptly incurved through 80° to suture, basal margin slightly angulately concave, disc slightly convex, almost flat, median carina distinct, vertex twice as broad as long in middle line, anterior margin obtusely angulate, posterior margin subparallel to anterior, lateral margins slightly diverging distally, disc slightly concave, median carina feeble. Rostrum scarcely surpassing mesotrochanters, apical segment scarcely shorter than subapical, apex very obliquely truncate. Pronotum in middle line about 1.2 times length of vertex in same line, a small impression on each side of middle, mesonotum in middle line slightly longer than pronotum, disc slightly tumid, anteriorly bounded by a fine transverse ridge parallel with hind margin of pronotum. Post-tibiae laterally 2-spined. Tegmina broadening distally, costal margin convex, apical margin convex-truncate, Sc + R forked near base, M forked slightly basad and Cu forked markedly distad of union of claval veins. Wings almost as long as tegmina, anal lobe reduced, apical margin slightly indented twice in Cu.

Anal segment of female relatively narrow, third valvulae broadly triangular, apical margin membranous, oblique.

Type species, *Kodaianella bicinctifrons,* new species.

Kodaianella bicinctifrons Fennah, new species.

(Figure 21, A–D; Figure 22, A–C.)

Male: length, 4.0 mm.; tegmen, 4.0 mm. Female: length, 3.9 mm.; tegmen, 4.2 mm.

Frons distinctly medially carinate, submarginal carinae feeble. Post-tibiae 11-spined at apex, basitarsus 12-spined distally.

Testaceous; basal half of frons and a more or less distinct band across middle of distal half, vertex, disc of pronotum, a band across lateral lobes of pronotum, and intercarinal areas of mesonotum, reddish-brown; sides of head below eyes and ventral portion of lateral lobes of pronotum, pallid yellow, hind legs and anteromedial portion of abdominal ventrites infuscate. Tegmina translucent testaceous lightly sprinkled reddish-brown as

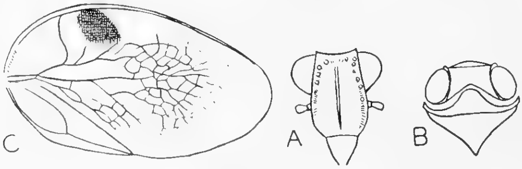


Fig. 20. *Hemisphaerius signifer* Wlk.: A, frons and clypeus; B, head and thorax; C, tegmen.

figured, with a narrow irregular fascia traversing middle. Wings fuscous, veins darker.

Anal segment long, relatively narrow, slightly expanding distally, apical margin semicircularly excavate, lateroapical angles more or less acutely produced, anal foramen in basal half. Pygofer with laterodorsal angles slightly prominent, rounded, lateral margin shallowly sinuate. Genital styles moderately short, about as wide near apex as at base, apical margin more or less abruptly transversely truncate, dorsal margin at middle produced dorsad in a large tapering lobe with anterior margin excavate in its dorsal third, apex acuminate, a short stout peg-like process laterally below apex. Aedeagus shallowly curved dorsad. Phallobase terminating dorsally in a median shagreen finger-like lobe directed cephalad with a triangular sclerotised spine at each angle; and ventrally in a pair of acutely rounded lobes. Phallus with a pair of long stout spines arising in distal half, directed ventrocephalad below aedeagus.

Posterior margin of pregenital sternite of female broadly produced caudad, margin of medial lobe truncate.

One male (the type), 800–1,000 ft., **Chang-Tau-Ching, Szechwan,** July 18, 1948, and 1 female, Sang-Hou-Ken, Hupeh-Szechwan Border, China, July 19, 1948, both taken by Gressitt.

This genus runs to *Samantiga* in Distant's key (1906: 351), but differs in the shape of the head, tegmina, and venation; it is superficially similar to *Kodaiana* Dist., but differs in the number of post-tibial spines and in the shape of the ovipositor; from *Sarima* it differs in the shape of the vertex, frons, and tegmina and in tegminal venation; and from *Narayana* in the structure of the head.

Duriopsilla Fennah, new genus

Frons longer in middle line than broad (1.2: 1), lateral margins sinuately diverging to below level of antennae, thence moderately incurved to

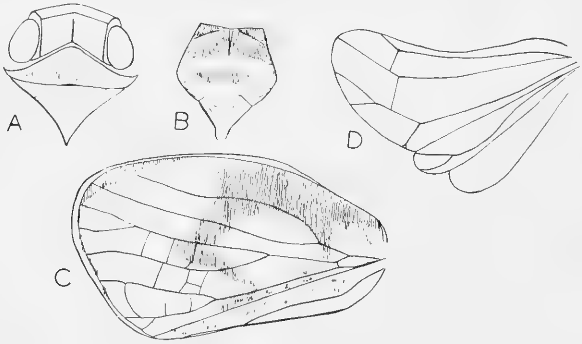


Fig. 21. *Kodaianella bicinctifrons,* new genus and species: A, head and thorax; B, frons and clypeus; C, tegmen; D, wing.

suture, disc markedly convex, carinae and lateral pustules feeble, merely indicated; vertex shallowly impressed, lateral and apical margins forming a semi-circle, posterior margin shallowly emarginate, slightly notched at middle, median carina distinct. Pronotum in middle line slightly longer than vertex, median carina feeble, an impression on each side of middle; mesonotum not quite as long as pronotum and vertex together. Rostrum reaching postcoxae, apical segment shorter than subapical, about three times as long as wide, apex transversely rounded-truncate. Pronotum with lateral lobes smooth; mesonotum twice as broad as long. Legs slender, femora not compressed; post-tibiae laterally 3-spined. Tegmina relatively narrow, costal and sutural margins straight, more or less parallel to level of node, symmetrically narrowing to acutely-rounded apex; Sc and R separate from base, M simple, Cu_1 forked slightly basad of middle of claval suture, claval suture distinct. Wings deeply incised in Cu.

Anal segment of female relatively short and broad, tapering distad. Third valvulae subequilaterally triangular, apical margin submembranous, tumid. Posterior margin of pregenital sternite transverse.

Type species, *Duriopsilla retarius,* new species.

Duriopsilla retarius Fennah, new species.
(Figure 25, A–D.)

Vertex broader than long (1.2:1). Post-tibiae 8-spined at apex; basal metatarsal segment 9-spined at apex.

Ochraceous; frons yellow; clypeus yellowish-brown, rostrum, hind margin of pronotal disc, lateral edge of lateral pronotal lobes, mesonotal disc medially, legs except at joints, hind basitarsi, sometimes median area of abdominal ventrites, fuscous; pleurites immediately below base of costal margin of tegmina fuscous-piceous.

Tegmina fuscous, heavily and uniformly covered with minute pallid reticulum of veinlets; veins dull greenish yellow.

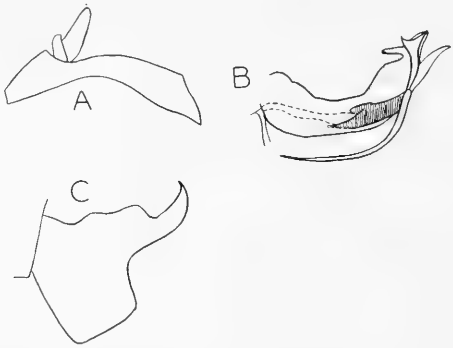


Fig. 22. *Kodaianella bicinctifrons*, new genus and species: A, anal segment of male, left side; B, aedeagus, left side; C, left genital style.

Anal segment of male triangular, broader than long, lateral angles deflexed.

Base of first valvulae of ovipositor as figured.

One male (the type) and 1 female, **1,000 m., Suisapa, Lichuan District, W. Hupeh, China,** July 25, 1948, Gressitt. This genus is similar to *Duriopsis,* but differs in the absence of a median carina on the clypeus, and of lateral mesonotal carinae; in the 3-spined post-tibiae, and the complete separation of Sc and R in the tegmina.

Genus **Gelastyra** Kirkaldy

Kirkaldy, 1904:280. Haplotype, *Issus testudinarius* Stål, 1854:246

Gelastyra biplaga (Wlk.), new combination.

(Figure 23, E, H.)

Issus biplaga Walker, 1851:367.

Female: length, 5.4 mm.; tegmen, 5.0 mm.

Vertex broader than long (1.8:1); post-tibiae 7-spined at apex, basal metatarsal segment 11-spined at apex.

Testaceous, tinged green; frons except for a round spot slightly basad of middle minutely and heavily speckled fuscous; anterior half and middle of pronotum, mesonotal disc laterally, a series of six oblique stripes on each side of middle line of clypeus, brown; transverse sulcus at base of frons piceous. Tegmina pallid, sub-translucent, basal quarter, except veins, and a broad band from middle of costa to sutural margin distad of apex of clavus, except veins, chocolate brown; veins green, pallid portion of tegmina tinged with green except in a broadly ovate area one-third from base.

Pregenital sternite produced posteriorly in a stout subspatulate process slightly broader than long. Third valvulae stout, broadly triangular, apical margin membranous. Anal segment narrowly ovate and laterally decurved distad of anal foramen.

One female, Hong Kong, Oct., 1895, Koebele. This species, which is not included in Melichar's monograph, runs to the *spectans* Wlk.–*latifrons* Mel. section of Melichar's key (1906:263) but differs from both in the shape of the vertex and of the carinae in the basal part of the frons.

Neodurium Fennah, new genus

Frons in middle line longer than broad (about 1.2:1), lateral margins almost straight, diverging to below level of antennae thence incurved to suture; disc shallowly convex, strongly depressed in middle near frontoclypeal suture, leaving lateroapical areas prominent; median carina strongly developed on basal three-quarters, more feeble in apical quarter; a pair of weak but distinct sublateral carinae enclosing an elongate-oval area of disc, strongly incurved basally to meet transversely at middle line, vertex subturbinate, apical margin subrectangulately convex, posterior margin obtusely angulately excavate, lateral margins straight, slightly converging apically; disc hollowed out, finely carinate throughout in middle line; sides of head shallowly grooved between lower margin of eye and frontoclypeal suture, clypeus ecarinate, convex, latero-basally slightly overhung by latero-apical area of frons; rostrum slightly surpassing mesotrochanters, apical segment shorter than subapical, very obliquely truncate at tip. Pronotum in middle line about as long as vertex, medially carinate with a small depression on each side of mid-line, lateral lobes with four short parallel ridges near posterior margin; at least twice as broad as long, mesonotum shorter than combined lengths of pronotum and vertex, finely medially carinate, even where medially depressed, lateral carinae short, strongly anteriorly convergent, separated from median carina posteriorly by a ridge or convexity of disc.

Pro- and mesofemora compressed, post-tibiae laterally with a spine near base and two large spines distally, apically with 8 spines, basal metatarsal

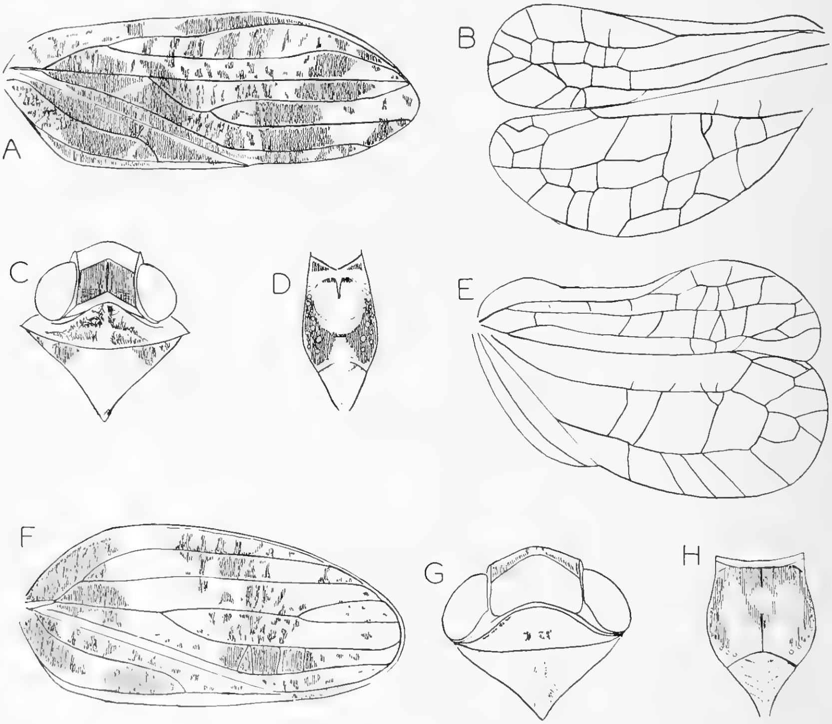


Fig. 23. *Tetricodes polyphemus*, new species: A, tegmen; B, wing; C, head and thorax, dorsal view; D, frons and clypeus. *Gelastyra biplaga* (Wlk.): E, wing; F, tegmen; G, head and thorax, dorsal view; H, frons and clypeus.

segment with about 13 spines. Tegmina with costal and sutural margins parallel to level of node, apical margin deeply and asymmetrically rounded, Sc and R arising separately from base, M simple, Cu forked basad of union of claval veins, claval suture absent, united claval vein continued to sutural angle then curving into feeble submarginal vein. Wings large, deeply incised on apical margin into two lobes, anal lobe not present, veins simple, distal venation coarsely reticulate.

Pregenital sternite of female with posterior margin shallowly excavate medially. Ovipositor with third valvulae stout, strongly convex, their apical margins tumid, polished, and bounding a lenticular cavity when apposed.

Type species, *Neodurium postfasciatum*, new species.

Neodurium postfasciatum Fennah, new species

(Figure 24, E–I.)

Female: length, 5.0 mm.; tegmen, 5.1 mm.

Vertex broader than long in middle line (1.8: 1). Profemora foliately expanded in apical half, mesofemora compressed, protibiae with subfoliate margins, basal metatarsal segment with 13 spines.

Testaceous-brown, finely sprinkled fuscous; a pair of ocellate spots at base of vertex, clypeus, and a broad band near apex of profemora, fuscous piceous. Tegmina tawny-gold, with darker suffusion and piceous spots and marbling on all areas except a broad band from immediately distad of node to estimated position of apex of clavus, and between hind margin and united claval veins. Wings translucent-fuscous with darker veins. Abdominal ventrites suffused fuscous; third valvulae of ovipositor ochraceous dorsally, fuscous ventrally, with a broad piceous band adjoining polished dull yellow tumid margin.

Anal segment of female short, lateral margins strongly convex, apex subacutely rounded. Third valvulae of ovipositor, when apposed, in ventral view about twice as broad as long. Base of first valvulae and posterior margin of seventh sternite as figured.

Three females (one the type), **1,000 m., Suisapa, Lichuan District, W. Hupeh, China,** Aug. 19, 20, 1948, Gressitt. The genus *Neodurium* differs from *Duriopsis* Mel., which it resembles, in shape of frons, proportions of mesonotum, and tegminal venation, and from *Flavina* Stål in proportions of frons, shape of legs, and absence of a claval suture in the tegmina; it also differs from both in the number of post-tibial spines.

Tetricodes Fennah, new genus

Vertex broader than long (2: 1), anterior margin obtusely angulately produced, lateral margins slightly convergent anteriorly, posterior margin subangulately emarginate, disc sloping down to middle line, median carina absent; frons longer than broad (1.3: 1), basal margin shallowly excavate, lateral margins shallowly convex, disc with median carina present only basally, otherwise tumid in basal half, position of sublateral carinae marked by shallow groove, frontoclypeal suture slightly impressed, rostrum attaining post-trochanters. Pronotum short, extremely narrow behind eyes, in middle line slightly longer than vertex; mesonotum slightly longer than pronotum. Post-tibiae armed with two stout spines in distal half, a minute tooth sometimes at extreme base, eight teeth at apex, basal metatarsal joint as long as other two combined. Tegmina with costal and sutural margins parallel, the former gradually rounding into oblique apical margin which is acutely bent at M_4, Sc + R fork one-quarter from base, each limb simple to apex, M three-branched, Cu_1 simple, union of claval veins level with fork of M. Wings larger than tegmina, with broadly reticulate venation, margin deeply cleft in Cu, anal lobe absent.

Anal segment of female moderately elongate, parallel sided and distally rounded. Ovipositor with third valvulae stout, triangular, with thick, tumid, pellucid apical margin.

Type species, *Tetricodes polyphemus,* new species.

Tetricodes polyphemus Fennah, new species.
(Figure 23, A–D.)

FEMALE: length, 5.2 mm.; tegmen, 5.5 mm.

Tegmina with apex of R curved toward M, M_3 distilly uniting with M_{1+2}.

Ochraceous to pallid with scattered greenish suffusion; discs of vertex and pronotum, except in middle line, and disc of mesonotum orange-brown and sepia; a polished tumescence on frons and a suffusion over distal quarter, a narrow triangle before eyes, and a spot on mesopleura, piceous; most of clypeus, lateral lobes of pronotum near margin, except for a few greenish pustules, a pair of transverse bands on femora, a suffusion on pro- and mesotibiae distally, abdomen dorsally and ventrites 4 to 7, fuscous. Tegmina dark sepia marbled with transverse veins and parts of longitudinal veins emerald and pallid green. Wings fuscous.

One female, **1,000 m., Suisapa, Lichuan District, W. Hupeh, China,** Aug. 21, 1948, Gressitt.

In Melichar's key to Thioniinae (1903:254) this species runs to "7," but it differs from both alternatives; from *Flavina* Stål in the form of the head and in the number of post-tibial spines, and from *Cameruniella* Hagl. in tegminal and wing venation. If *Flavina ? striata* Dist. belongs in this genus, it is separated from *T. polyphemus* by coloration, especially of the frons.

Genus **Tetrica** Stål

Stål, 1866:208. Logotype, *Tetrica fusca* Stål, 1870:757

It appears likely that this genus, as currently recognized, is composite or contains groups of species which might be recognized as distinct subgenera: it is also possible that species have been assigned to *Sarima* Mel. by their authors because they did not agree with their interpretation of *Tetrica*. Melichar's concept of *Sarima* is restricted to species in which the two veins which adjoin the first fold of the wings are fused together distally to form a single stout rod. On account of this restriction the following two species fall into the looser concept of *Tetrica* Stål.

Tetrica zephyrus Fennah, new species.
(Figure 24, A–D.)

FEMALE: length, 5.5 mm.; tegmen, 6.0 mm.

Lateral margins of frons evenly incurved distally through less than 90°. Rostrum with apical segment markedly expanding distally in anterior view, at apex twice as wide as at base of subapical segment. Post-tibiae laterally bispinose, apically 7-spined: basal metatarsal segment with 9 spines. Tegmina with Sc reaching to middle of costal margin, of subequal prominence throughout.

Testaceous; a suffusion anteriorly on vertex, over frons except in basal fifth and clypeus except at sides, genae before eyes and abdominal ventrites fuscous, a narrow band across base of frons, excluding transverse carinae,

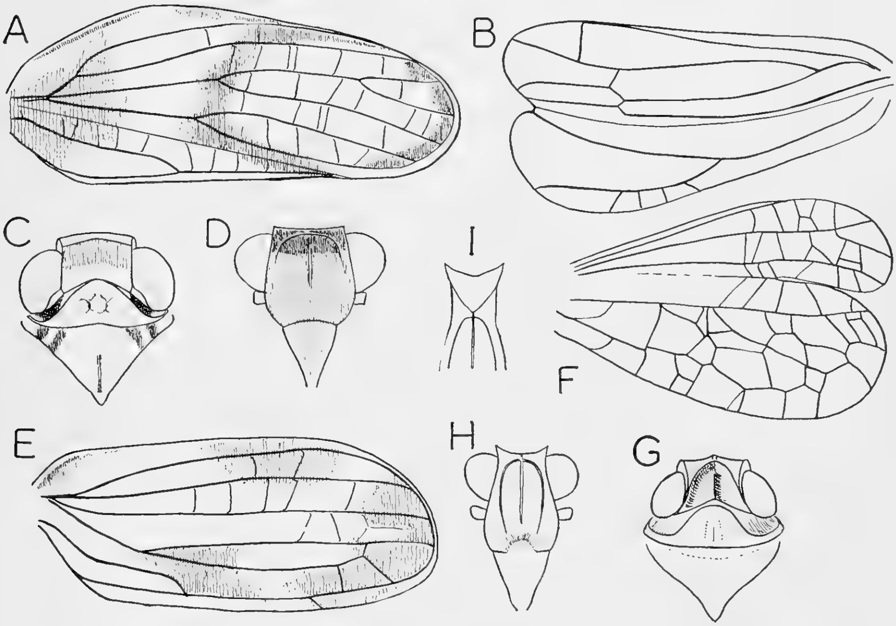


Fig. 24. *Tetrica zephyrus*, new species: A, tegmen; B, wing; C, head and thorax; D, frons and clypeus. *Neodurium postfasciatum*, new species: E, tegmen; F, wing; G, head and thorax; H, frons and clypeus; I, apex of vertex, anterodorsal view.

a spot anterolaterally on pronotum underlying basal surface of head, two bands near each side of mesonotum, and tibiae at apex, fuscous-piceous.

Tegmina greyish-translucent, a diffuse fascia from base of clavus across humeral eminence to costal margin, an irregular and interrupted V-shaped suffusion from apex of clavus to fork of Cu, thence obliquely to costal margin near node, brown; intervenal submarginal areas of costa and apex dark fuscous. Wings fuscous.

Deflexed part of anal segment of female about 5 times as long as broad. Ovipositor with third valvulae triangular, castaneous, polished, narrowly membranous at tip, which is subacute.

Two females (one the type), **Mokansan, Che-Kiang Province, China,** Aug. 24, 1927, Mrs. D. E. Wright. This species differs from *T. aequa* Jac. in coloration and from *S. bimaculata* Mel. and *S. clathrata* Mel. in the position of the union of the frontal carinae, and in the color and pattern of the tegminal markings, from *S. amagisana* Mel. in coloring of frontal carinae and tegmina, and from *S. sinensis* (Wlk.) in the much less angulate anterior margin of the vertex.

It is just possible that it may prove to be a geographical subspecies of *Sarima nigrifacies* Jac., though it differs substantially from the described coloration, while it cannot be assumed that the species are congeneric. The decision to erect a new species, based only on female material, was taken by the writer after he had satisfied himself that the nuances of shape of the head and its carinae, and of the tegmina and their venation furnish adequate means of specific recognition.

Genus **Caliscelis** Laporte

De Laporte, 1833:251. Haplotype, *Fulgora bonelli* Latr., 1807:166

Caliscelis chinensis Mel.

Melichar, 1906:16.

Post-tibiae laterally with 1 spine; apically with 7 short stout spines. Basal metatarsal segment 2-spined.

Ovipositor with third valvulae thickened and slightly tumid on hind margin near base.

One female, Tunglu, Che Kiang Province, China, Sept. 10, 1926, Mrs. D. E. Wright.

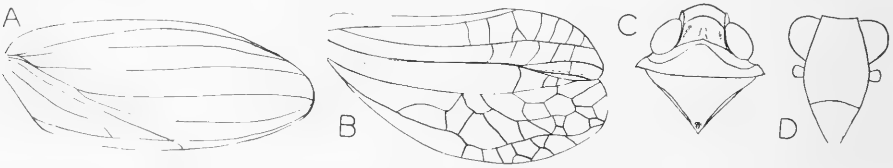


Fig. 25. *Duriopsilla retarius*, new genus and species: A, tegmen; B, wing; C, head and thorax; D, frons and clypeus.

Family **FLATIDAE** Spinola

KEY TO GENERA OF CHINESE FLATIDAE

(1) (2) Tegmina in respose steeply tectiform, their apical margins more or less contiguous throughout .... (3)

(2) (1) Tegmina very shallowly tectiform, almost horizontal, in repose, their apical margins not contiguous. Post-tibiae with one spine laterally .... *Atracis* Mel.

(3) (4) Antennae relatively elongate, basal segment at least three times as long as broad. Post-tibiae six-spined at apex, basal metatarsal segment with four spines at apex. Species large .... *Cerynia* Stål

(4) (3) Antennae short, not as above .... (5)

(5) (6) Tegmina with costal margin curving obtusely into apical margin, apex of clavus reaching to anal angle, or practically so .... (7)

(6) (5) Tegmina not as above, apical angle well defined, or if not then more or less symmetrical with anal angle .... (9)

(7) (8) Tegmina with anal angle acute and produced .... *Mimophantia* Mats.

(8) (7) Tegmina with anal angle obtusely rounded, not produced .... *Microflata* Mel.

(9) (10) Tegmina distinctly constricted between node and claval apex, apical margin rounded .... *Seliza* Stål

(10) (9) Tegmina not constricted as above .... (11)

(11) (12) Tegmina with apical cells short, devoid of a distinct even line of transverse veinlets .... (13)

(12) (11) Tegmina with apical cells not short, at least one even and distinct transverse line .... *Phylliana* Merc.

(13) (14) Vertex conically produced. Anal angle of tegmina acute .... (15)

(14) (13) Vertex obtusely rounded. Anal angle of tegmina subrectangulate, costal cell reticulate .... *Geisha* Kirk.

(15) (16) Costal cell of tegmina densely reticulate. Vertex medially carinate .... *Phyllyphanta* A. & S.

(16) (15) Costal membrane traversed by regularly spaced subparallel veinlets. Vertex not medially carinate .... *Salurnis* Stål

Genus Mimophantia Matsumura

Matsumura, 1900:212. Haplotype, *Mimophantia maritima* Mats.

Mimophantia maritima Mats.

Matsumura, 1900:212.

Third valvulae of ovipositor with 5 teeth on outer margin and one tooth on upper. Post-tibiae 2-spined laterally, 8-spined at apex, basal metatarsal segment with about 20 spines.

Four males and 9 females, Mokansan, Che Kiang Province, China, Sept. 10, 16, 18, 1927, Mrs. D. E. Wright.

Genus **Microflata** Melichar

Melichar, 1902:9. Haplotype, *Microflata stictica* Mel.

Microflata stictica sinensis Fennah, new subspecies.
(Figure 26, A–C.)
Melichar, 1902:10.

Width of vertex at level of anterior margin of eye slightly exceeding length in middle line, apical margin obtusely convex.

Tegmina with corium testaceous, translucent, distal main veins and area between hind claval vein and margin fuscous. Lateral margins of seventh and eighth abdominal segments piceous.

One female, Loh-Fau Shan, Poh-lo District, Kwang Tung, China, April 6–8, 1934. In the typical subspecies the length of the vertex slightly exceeds its width at the level of the anterior margin of the eyes, while the anterior margin is subacutely convex; a broad shallow ridge lies along the middle line from apex to base, whereas on the frons the median carina does not extend distad of the middle. In the present subspecies there is no definite median ridge on the vertex, while the median carina of the frons can be traced almost to the fronto-clypeal suture.

Genus **Salurnis** Stål

Stål, 1870:773. Type, *Ricania marginella* Guérin-Méneville

Salurnis marginellus (Guér.).
Ricania marginella Guérin-Méneville 1834:467

Post-tibiae unispinose laterally, apically 8-spined, basal metatarsal segment 12-spined.

One male and 2 females, Chang-Tau-Ching, 800–1,000 ft., Szechwan, China, Gressitt, July 18, 1948; 1 female, Sang-Hou-Ken, Hupeh-Sze border, China, July 19, 1948.

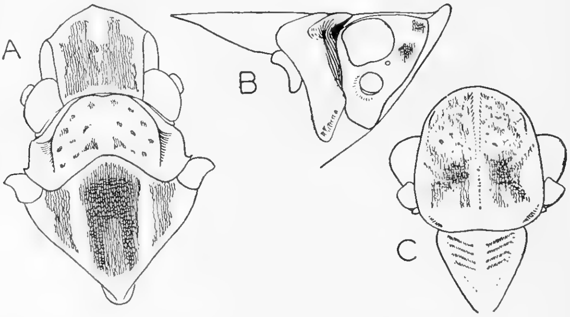


Fig. 26. *Microflata stictica sinensis*, new species: A, head and thorax; B, ditto, side view; C, frons and clypeus.

Genus **Geisha** Kirkaldy

Kirkaldy, 1900:296. Type, *Poeciloptera distinctissima* Wlk.

Geisha distinctissima (Wlk.).
Poeciloptera distinctissima Walker, 1858:114.

Post-tibiae laterally bispinose, apically 7-spined, basal metatarsal segment 8-spined.

Two females, 1,000 m., Suisapa, Lichuan District, W. Hupeh, China, July 25, 1948, Gressitt; 1 male, Tokyo, Japan, July, 1900, Kuwana; one female, Chizuka, Okinawa, July–Sept., 1945, Bohart and Harnage, is provisionally placed here.

Genus **Phylliana** Metcalf

Metcalf, 1952:227. Logotype, *Mesophylla inclinata* Mel., 1902:53

Two females, Kwanhaien, Che Kiang Province, China, Aug. 2, 1928, H. S. Parish, are referred to this genus but do not agree with any species so far described. They may be related to *M. alba* Jac. from Luzon.

Genus **Cerynia** Stål

Stål, 1866:235. Type, *Flata albata* Stål, 1854:247

Cerynia maria rosea Mel.
Poeciloptera maria White, 1846:25, pl. 1, fig. 3, var. *rosea* Melichar, 1901:220.

One male, Lung Tau Shan, N. Kwangtung, China, June 11, 1947, Gressitt.

Genus **Seliza** Stål

Stål, 1862:303. Orthotype, *Poeciloptera vidua* Stål, 1854:248

Seliza ferruginea lignaria (Wlk.).
Elidiptera ferruginea Walker, 1851:333.
Flatoides lignarius Walker, 1851:413.

Post-tibiae 2-spined, 6-spined at apex, basal metatarsal segment 7-spined.

One male, Lung Tau Shan, N. Kwangtung, China, July 11, 1947, Gressitt. Until a critical study of this genus can be made, the writer believes the above to represent the most satisfactory taxonomic assignment of the populations of this species found in Hong Kong and Kwangtung.

Family **NOGODINIDAE** Muir

Genus **Pisacha** Distant

Distant, 1906:391. Orthotype, *Pisacha naga* Distant

Pisacha naga Distant
Distant, 1906:392.

One female, Nai-suen, 21 m. northeast of Naam-fung, Lin-kao District, Hainan Island, Sept. 1, 2, 1932.

Genus **Mindura** Stål

Stål, 1862:69. Orthotype, *Flata obscura* F., 1803:49

Mindura sundana Kirkaldy.
Mindura sundana Kirkaldy, 1909:32.
Mindura fuscata Melichar, 1898:212.

Rostrum surpassing post-trochanters. Post-tibiae laterally 4-spined, apically 9-toothed; basal metatarsal segment with two prominent outer teeth and 11 small teeth between them. Ovipositor with third valvulae distally heavily callused, each with about 15 minute teeth on inner face just basad of thickened area; a prominent membranous triangular lip projecting at apex.

One female, Chizuka, Okinawa, July–Sept., 1945, C. E. Bohart and C. L. H. Harnage.

Family **LOPHOPIDAE** Stål

KEY TO GENERA OF CHINESE LOPHOPIDAE

(1) (2) Post-tibiae at apex with a pad of fused spines separated only at their tips .... (3)

(2) (1) Post-tibiae at apex with large spines, sublinear or irregular; median disc of frons without a median carina; in profile vertex meeting frons acutely .... *Bisma* Dist.

(3) (4) Basal joint of metatarsus inflated, with its lower surface covered with a felt of minute setae .... (5)

(4) (3) Basal joint of metatarsus narrow with a pad of spines on its distal edge .... (7)

(5) (6) Vertex longer than broad, base of median disc of frons in anterior view extending dorsad beyond remainder of frons, no part of frons visible in anterior view between median disc and eyes; tegmina with sutural angle acute .... *Lophops* Spin.

(6) (5) Vertex broader than long, base of median frontal disc not surpassing basal margin of frons, median disc not occupying whole width of frons; tegmina with sutural angle obtusely rounded .... *Lacusa* Stål

(7) (8) Second post-tarsal segment as large as basal segment; apical margin of tegmina convex, protibiae flattened but not dilated .... *Pitambara* Dist.

(8) (7) Second post-tarsal segment much smaller than basal; apical margin of tegmina more or less straight and oblique; protibiae greatly dilated .... *Elasmoscelis* Spin.

Genus **Lophops** Spinola

Spinola, 1839:387. Orthotype, *Lophops servillei* Spin.

Lophops carinata (Kirby).
Brixioides carinatus Kirby, 1891:140.

One male and one female, Sam-ah-Kong, Yei-hsien District, Hainan Island, S. China, Jan. 24–26, Feb. 1, 1935; one female, Big Pool, 2,800 ft., Loh Fau Shan, Kwangtung, S. China, Oct. 11, 1935, E. R. Tinkham.

Genus **Lacusa** Stål

Stål, 1862:309. Haplotype, *Lacusa fuscofasciata* Stål

Lacusa fuscofasciata (Stål).
Elasmoscelis ? fuscofasciata Stål, 1854:248.

One female, between Cheung-kon-ts'uen and Tai-pin-ts'uen, Kuing-shan District, Hainan Island, S. China, July 19, 1935; one female, Lung-Tau Shan, N. Kwangtung, June 11, 1947, Gressitt.

Genus **Elasmoscelis** Spinola

Spinola, 1839:388. Orthotype, *Elasmoscelis cimicoides* Spinola, 1839:388

Elasmoscelis perforata Walker.

One male and 1 female, Tokao, Japan, Oct., 1907, H. Salter; 1 female, Taipingfu, Sung-shan District, Kwangsi, S. China, Aug. 5–6, 1934, E. R. Tinkham; 1 female, Nai-Suen, 21 m. southeast of Naam-fung, Lin-kao District, Hainan Island, Sept. 10–12, 1932.

Family **RICANIIDAE** Stål

Genus **Ricania** Germar

Germar, 1818:221. Logotype *Cercopis fenestrata* Fabricius, 1775:688
= *Flata hyalina* F.

Ricania speculum (Walker).
Flatoides speculum Walker, 1851:406.

In the series examined the markings on the tegmina were comparatively uniform. One male, Sang-Hou-ken, Hupeh-Sze border, July 19, 1948, Gressitt; 6 males and 4 females, 800–1,000 ft., Chang-Tau-Ching, Szechwan, July 18, 1948, Gressitt.

Genus **Pochazia** Amyot & Serville

Amyot and Serville, 1843:528. Logotype, *Flata fasciata* Fabricius, 1803:47

Pochazia fuscata (F.).
Cicada fuscata Fabricius, 1794:28.

Two males and 2 females, Taihanroku, Japan, June 30, 1908, H. Salter, belong to the geographical subspecies *albomaculata* Uhler.

REFERENCES

Amyot, C. J. B., and J. G. A. Serville

1843. Histoire Naturelle des Insectes. Hémiptères, i–lxxvi; 1–676.

Bierman, C. J. H.

1908. Homopteren aus Semarang (Java) gesammelt von Herrn. Edw. Jacobson. *Notes from the Leyden Museum*, 29:151–169, pls. 3, 4.

1910. Homopteren aus Niederlandisch Ost-Indien. II Herausgegeben von D. MacGillivray und K. W. Dammerman. *Notes from the Leyden Museum*, 33:1–68; pls. 1–2.

Boheman, C. H.

1847. Nya Svenska Homoptera. *Handlingar Svenska Vetenskapsakademien*, 23–67.

Butler, A. G.

1875. List of the species of the Homopterous genus *Hemisphaerius*, with descriptions of new forms in the collection of the British Museum. *Annals of Natural History, or Magazine of Zoology, Botany and Geology*, (4) 16:92–100; pl. 4.

China, W. E.

1925. The Hemiptera collected by Prof. J. W. Gregory's Expedition to Yunnan, with synonymic notes on allied species. *Annals of Natural History or Magazine of Zoology, Botany and Geology*, (9) 16:449–485; figs. 1–5.

Distant, W. L.

1892. Contribution to a knowledge of the homopterous family Fulgoridae. *Transactions of the Entomological Society of London*, 275–286.

1906. Bibliographical and Nomenclatorial notes on the Rhynchota. *The Entomologist*, 39:274–275.

1906. Rhynchota. Heteroptera–Homoptera. The Fauna of British India, including Ceylon and Burma, vol. 3:i–xiv, 52–491, figs. 31–266.

1909. Rhychotal Notes. xlviii. *Annals of Natural History or Magazine of Zoology, Botany and Geology*, (8) 4:73–87.

1911. Descriptions of new genera and species of Oriental Homoptera. *Annals of Natural History, or Magazine of Zoology, Botany and Geology*, (8) 8:639–649.

1912. Descriptions of new genera and species of Oriental Homoptera. *Annals of Natural History, or Magazine of Zoology, Botany and Geology*, (8) 9:181–194.

1916. Rhynchota. Homoptera: Appendix. The Fauna of British India, includ ing Ceylon and Burma. Vol. 6:i–vii, 1–248; figs. 1–177.

Donovan, E.

1800. Homoptera, in "An epitome of the natural history of the insects of India, and the islands in the Indian Seas. . . ." Pages and plates not numbered.

FABRICIUS, J. C.

1775. Ryngota. Systema entomologiae: 673–689.

1794. Ryngota. Entomologia systematica: 1–57.

1803. Rhyngota. Systema Rhyngotorum: 1–101.

FENNAH, R. G.

1944. New Dictyopharidae from the New World (Homoptera: Fulgoroidea). *Proceedings of the Biological Society of Washington*, 57:77–94, figs. 1–48.

1949. New exotic Fulgoroidea. *Annals of Natural History, or Magazine of Zoology, Botany and Geology*, (12) 2:585–606; figs. 1–14.

FIEBER, F. X.

1866. Grundzüge zur generischen Theilung der Delphacini. *Verhandlungen Zoologisch-Botanische Gesellschaft, Wien*, 16:517–534; pl. 8.

1875. Les Cicadines d'Europe d'après les originaux et les publications les plus récentes. *Revue et Magasine de Zoologie pure et appliquée*, (3) 3:288–416.

1876. Les Cicadines d'Europe d'après les originaux et les publications les plus récentes. *Revue et Magasine de Zoologie pure et appliquée*, (3) 4:11–268, pls. 3–13.

GERMAR, E. F.

1818. Bemerkungen über einige Gattungen der Cicadarien. *Magazin der Entomologie*, 3:177–227.

1833. Conspectus generum Cicadariarum. Revue Entomologique, publiée par Gustave Silbermann. 1:174–184.

GUÉRIN-MÉNEVILLE, F. E.

1834. Essai d'un nouvel arrangement des Hémiptères de la section der Homoptères. Voyage aux Indes-Orientales, publié par M. C. Bélanger. Zoologie. Insectes: 445–480; pl. 3.

HORVATH, G.

1899. Hémiptères de l'ile de Yesso (Japon). *Természetrajzi Füzetek*, 22:365–374; figs. 1–2.

JACOBI, A.

1944. Die Zikadenfauna der Provinz Fukien in Südchina und ihre tiergeographischen Beziehungen. *Mitteilungen der Münchner Entomologischen Gesellschaft*, 34:5–66; figs. 1–16.

KIRBY, W F.

1891. Catalogue of the described Hemiptera Heteroptera and Homoptera of Ceylon, based on the collection formed (chiefly at Pundaloya) by Mr. E. Ernest Green. *Journal of the Linnean Society, Zoology*, 24:126–174; pls. 5–6.

KIRKALDY, G. W.

1900. On the nomenclature of the genera of the Rhynchota, Heteroptera and Auchenorrhynchous Homoptera. *The Entomologist*, 33:25–28; 262–265.

KIRKALDY, G. W. (Cont.)

1900. Bibliographical and nomencatorial notes on the Rhynchota. No. 1. *The Entomologist*, 33:238–243.

1901. Miscellanea Rhynchotalia. *The Entomologist*, 34:5–6.

1902. Memoirs on Oriental Rhynchota. *Journal of the Bombay Natural History Society*, 14:46–58; 294–309.

1904. Bibliographical and nomenclatorial notes on the Hemiptera. No. 3. *The Entomologist*, 37:279–283.

1906. Leafhoppers and their natural enemies. Pt. IX Leafhoppers. Hemiptera. *Bulletin, Hawaiian Sugar Planters' Association Experiment Station*, 1(9):271–479; pls. 21–32.

1907. Leafhoppers. Supplement (Hemiptera) *Bulletin, Hawaiian Sugar Planters' Association Experiment Station*, 3:1–186; pls. 1–20.

1909. Hemiptera: New and Old No. 1. *The Canadian Entomologist*, 41:30–32.

KOLENATI, F.

1857. Homoptera Latreille. Leach. Gulaerostria Zetterstedt, Meletemata Entomologica. *Bulletin de la Société Impériale des Naturalistes de Moscou*, 30:399–429; pls. 5–6.

DE LAPORTE, F. L.

1833. Note sur un nouveau genre et un nouvel insecte Homoptère. *(Caliscelis heterodoxa). Annales de la Société entomologique de France*, 2:251–253.

LATREILLE, P. A.

1804. Cicadaires; cicadariae. Histoire naturelle, générale et particulière des Crustacés et des Insectes. 12:293–337; pls. 96–97.

1807. Cicadariae. Genera Crustaceorum et Insectorum. 3:152–168.

LETHIERRY, L. F.

1888. Liste des Hémiptères receullis à Sumatra et dans l'ile Nias par Mr. E. Modigliani. *Annali del Museo Civico di Storia Naturale di Genova*, (2) 6:460–470.

LINNÉ, C.

1767. II Hemiptera. Systema Naturae . . . 1 (2):703–712.

MATSUMURA, S.

1900. Übersicht der Fulgoriden Japans. *Entomologisches Nachrichtenblatt*, 26:205–213; 257–269.

1906. Die Hemipteren Fauna von Riukiu (Okinawa). *Transactions of the Sapporo Natural History Society*, 1:15–38; pl. 1.

1907. Monographie der Homopteren-Gattung, *Tropidocephala* Stål. *Annales Historico-Naturales Musei Nationalis Hungarici*, 5:56–66; pls. 1–2.

1914a. Die Cixiinen Japans. Annotationes Zoologicae Japonenses. 8:393–434; figs. 1–3.

1914b. Beitrag zur Kenntnis der Fulgoriden Japans. *Annales Historico-Naturales Musei Nationalis Hungarici*, 12:261–305; figs. 1–16.

1916. Synopsis der Issiden (Fulgoriden) Japans. *Transactions of the Sapparo Natural History Society*, 6:85–118.

Matsumura, S. (Cont.)

1935. Supplementary Note to the revision of *Stenocranus* and allied species of Japan-Empire. *Insecta Matsumurana*, 10:71–78.

— and T. Ishihara

1945. Species novae vel cognitae Araeopidarum imperii japonici (Hemiptera). *Mushi*, 16:59–82; figs. 1–58.

Melichar, L.

1901. Monographie der Acanaloniiden und Flatiden (Homoptera). *Annalen des K. K. Naturhistorischen Hofmuseums, Wien.* 16:178–258.

1902. Monographie der Acanaloniiden und Flatiden (Homoptera) (Fortsetzung). *Annalen der K. K. Naturhistorischen Hofmuseums, Wien*, 17:1–123; pls. 1–9.

1903. Homopteren-Fauna von Ceylon: i–iv, 1–248; pls. 1–6.

1906. Monographie der Issiden. *Abhandlungen der K. K. Zoologisch-botanischen Gesellschaft in Wien*, 3:1–327; figs. 1–75.

1912. Monographie der Dictyophorinen (Homoptera). *Abhandlungen der K. K. Zoologische-Botanischen Gesellschaft in Wien*, 7 (i):1–221; pls. 1–5.

Metcalf, Z. P.

1948. General Catalogue of the Hemiptera. Fasc. IV Fulgoroidea. Part 10 Achilidae: 1–87.

1952. New names in the Homoptera. *Journal of the Washington Academy of Sciences*, 42:226–231.

Muir, F. A. G.

1913. On some new species of leafhoppers. Part II. Derbidae. *Bulletin, Hawaiian Sugar Planters' Association Experiment Station*, 12:28–92; pls. 1–3.

1913. On some new Fulgoroidea. *Proceedings of the Hawaiian Entomological Society*, 2:237–269; pl. 6.

1915. New and little-known Derbidae. *Proceedings of the Hawaiian Entomological Society*, 3:116–136.

1915. A contribution towards the taxonomy of the Delphacidae. *The Canadian Entomologist*, 47:317–320.

1916. Additions to the known Philippine Delphacidae (Hemiptera). *Philippine Journal of Science*, 11:369–385.

1917. The Derbidae of the Philippine Islands. *Philippine Journal of Science*, 12:49–105; pl. 1.

1917. Homopterous Notes. *Proceedings of the Hawaiian Entomological Society*, 3:311–338; pl. 6.

1918. Notes on the Derbidae in the British Museum Collection. *Entomologist's Monthly Magazine*, 54:173–177; 202–207; 228–243.

1925. A new species of *Oliarus* from China (Fulgoroidea, Homoptera). *Philippine Journal of Science*, 28:365–367; fig. 1.

Noualhier, J. M.

1896. Note sur les Hémiptères récoltès en Indo-Chine et offerts au Muséum par M. Pavie. *Bulletin du Muséum National d'Histoire Naturelle*, Paris. 10:251–259.

SCHAUM, H. R.

1850. Fulgorellae. Allgemeine Encyklopädie der Wissenschaften, Erster Section A–G. 51:58–73.

SIGNORET, V.

1860. Faune des Hémiptères de Madagascar, Homoptères. *Annales de la Société entomologique de France,* (3) 8:177–206; pls. 4–5.

SPINOLA, M.

1839. Essai sur les Fulgorelles . . . *Annales de la Société entomologique de France,* 8:133–337; 339–454; pls. 10–16, 17.

STÅL, C.

1853. Nya Genera bland Hemiptera. *Ofversigt af Kongliga Svenska Vetenskaps Akademiens Förhandlingar. Stockholm.* 10:259–267.

1854. Nya Hemiptera. *Ofversigt af Kongliga Svenska Vetenskaps Akademiens Förhandlingar,* 11:231–255.

1855. Nya Hemiptera. *Ofversigt af Kongliga Svenska Vetenskaps Akademiens Förhandlingar.* 12:181–192.

1859a. Novae quaedam Fulgorinorum formae speciesque insigniores. *Berliner Entomologische Zeitschrift,* 3:313–327.

1859b. Hemiptera. Kongliga Svenska Fregatten Eugenies resa omkring jorden under befal af C. A. Virgin aren 1851–1853. 4:269–298, pls. 3–4.

1862. Novae vel minus cognitae Homopterorum formae et species. *Berliner Entomologische Zeitschrift,* 6:303–315.

1863. Beitrag zur Kenntnis der Fulgoriden. *Entomologische Zeitung.* Herausgegeben von dem entomologischen vereine zu Stettin. 24:230–251.

1866. Hemiptera Homoptera Latr. Hemiptera Africana. 4:1–276; pl. 1.

1870. Hemiptera insularum Philippinarum. *Ofversigt af Kongliga Svenska Vetenskaps Akademiens Förhandlingar,* 27:707–776; pls. 8–9.

UHLER, P. R.

1896. Summary of the Hemiptera of Japan presented to the United States National Museum by Professor Mitzukuri. *Proceedings of the United States National Museum,* 19:276–297.

VAN DUZEE, E. P.

1897. A preliminary review of the North American Delphacidae. *Bulletin of the Buffalo Society of Natural Sciences,* 5:225–261.

WALKER, F.

1851. List of the specimens of Homopterous Insects in the collection of the British Museum. 2:261–636, pls. 3–4.

1857. Catalogue of the Homopterous insects collected at Singapore and Malacca by Mr. A. R. Wallace. *Journal of the Proceedings of the Linnean Society, London,* 1:141–175; pls. 7–8.

1858. Supplement. List of the specimens of Homopterous insects in the collection of the British Museum. 308–369.

Walker, F. (Cont.)

1862. Characters of undescribed species of Homoptera in the collection of F. P. Pasco, F.L.S. *The Journal of Entomology. Descriptive and Geographical*, 1:303–319; pl. 15.

1870. Catalogue of the Homopterous insects collected in the Indian Archipelago by Mr. A. R. Wallace. *Journal of the Linnean Society, Zoology*, 10:82–193; 276–330; pl. 3.

White, A.

1846. Descriptions of some apparently new species of Orthopterous and Homopterous insects. *Annals of Natural History or Magazine of Zoology, Botany and Geology*, 18:23–26; pl. 1.

PROCEEDINGS
OF THE
CALIFORNIA ACADEMY OF SCIENCES
Fourth Series

Vol. XXVIII, No. 14, pp. 529-560 September 21, 1956

HOLOTYPE SPECIMENS OF REPTILES AND AMPHIBIANS IN THE COLLECTION OF THE CALIFORNIA ACADEMY OF SCIENCES

By

JOSEPH R. SLEVIN
Curator, Department of Herpetology
California Academy of Sciences

and

ALAN E. LEVITON
Natural History Museum
Stanford University, California

INTRODUCTION

This paper has been prepared to make available to other workers information concerning the type material of reptiles and amphibians present in the collections of the California Academy of Sciences. The need for this work is considerable. As a result of the earthquake and fire which occurred in San Francisco in April, 1906, the building which housed the Academy's collections was destroyed. Much confusion has existed among herpetologists as to which holotypes were lost, which were saved, and what has subsequently happened to the collections.

HISTORY OF THE DEPARTMENT

The Department of Herpetology was organized in the year 1895 under the curatorship of Mr. John Van Denburgh, who had already begun his herpetological researches at Stanford University as a student. At the time the collection consisted of some odds and ends sent in by various friends of the Academy, including a very fine collection of reptiles and amphibians from Lower California and western Mexican states made under the direction of Dr. Gustav Eisen. These were housed, together with the fish, in the department headquarters in the museum building at 833 Market Street.

On Mr. Van Denburgh's departure for medical school at Johns Hopkins University, Baltimore, the department remained inactive until his return in 1902, when he resumed his curatorial duties. In May, 1904, Mr. Slevin was appointed assistant and under Dr. Van Denburgh's instruction was taught the art of preserving specimens and the care of the department's collections. At the same time short trips were made in the vicinity of San Francisco to become familiar with field work in preparation for the forthcoming Academy expedition to the Galapagos Islands. The expedition left San Francisco on June 28, 1905. While Mr. Slevin was absent in the field, Mr. John I. Carlson assisted in caring for the collections and did the necessary labeling and cataloging. When, on April 18, 1906, the great earthquake and fire destroyed the Academy, the entire collection, which at the time numbered 8,100 specimens, was entirely wiped out with the exception of thirteen specimens saved by the curator.

On the morning of the disaster Dr. Van Denburgh hurried to the museum to see if the building was in danger. Finding the fire spreading rapidly, he made his way to the department with all speed, his mind being set on saving the type specimens. He succeeded in saving ten of these, three miscellaneous specimens, as well as the department's catalog and Jan's *Iconographie*. These were housed in his home outside the fire limit and were kept there until the Academy again secured permanent quarters.

The expedition to the Galapagos Islands did not return until November 29, 1906, bringing back 4,506 specimens with which to start a new collection. The housing of the Galapagos material proved a problem owing to the damage done the previous April. However, the director of the Academy at that time, Mr. Leverett Mills Loomis, had a portion of a floor in the damaged building walled off before the return of the expedition, and the department was installed here until it became necessary to tear down the wreck of the building.

When the demolition of the building was about to take place the department moved to a vacant store on Turk Street, near Market Street. This move permitted the erection of temporary shelving, and with the purchase of glassware it became possible to begin sorting, labeling, and cataloging the Galapagos collections. This was fortunately completed before another move was made.

At about this time (1908), Dr. Joseph C. Thompson, M.D., and surgeon on duty with the United States Navy, joined the Academy's staff as assistant curator of herpetology. However, he was able to spend but little time at the Academy for his military obligations were constantly carrying him to remote regions. As a result of these military tours he was able to amass large herpetological collections, particularly from Japan, Formosa, and the Philippine Islands, these specimens being deposited in the department's collection. Dr. Thompson's association with the Academy was rather abruptly terminated just prior to June, 1912, as a result of several disagreements with Dr. Van Denburgh.

With the exception of the Department of Herpetology, whose collections were now of considerable size because of the Galapagos Expedition and Dr. Thompson's efforts, the Academy was housed in a residence at 1812 Gough Street. The Trustees decided it would be safer to have its possessions in a fireproof building and under one roof; another move was thus made to the Security Building at 343 Sansome Street. Here the department was housed until it made its final move in 1915 to its permanent quarters in Golden Gate Park.

With the improved conditions it was again possible to conduct field work, and the building up of the collections for the work on the reptiles of western North America was continued for the next eight years, with the exception of an interval during World War I, when Mr. Slevin was absent on duty with the Navy. The field work entailed numerous trips throughout the western states, and, in 1921, the Gulf of California. The results of these trips were summed up in a series of publications of the Academy, culminating in the massive work, *The Reptiles of Western North America,* which appeared in 1922.[1]

The untimely death of Dr. Van Denburgh, on October 24, 1924, during a vacation to Hawaii, left Mr. Slevin to carry on the work, first as assistant, and later as curator. Opportunities presented themselves to carry activities further afield, and, as it had always been Dr. Van Denburgh's idea to make a world-wide collection, advantage was taken of the opportunities offered. This resulted in several trips to Central America, including Guatemala, Panama, and Mexico, and three trips to Australia. In addition the collections were augmented by several exchanges with the Museum of Comparative Zoology of Harvard University, the British Museum (Natural History), and the Muséum d'Histoire Naturelle in Paris, and the purchase of a considerable part of the E. H. Taylor Philippine collection.

Unfortunately depressions and wars curtailed the activities enjoyed in former years and greatly retarded the growth of the collection. For the period of World War II departmental activity ceased when the curator joined the staff of the Academy's optical shop engaged in work for the Navy.

At the close of the war activities were again resumed. Several new field trips were undertaken, including participation in the Sefton Foundation expedition to the Gulf of California in 1953. Presently the curator, having recently completed his manuscript concerning the history of the Galapagos Islands, has turned his attention to the study of the Australian collections.

---

[1] Bibliographies of the department's staff members are presented at the conclusion of this paper.

Expeditions Engaged in by Department Members

Through the years the herpetology department has been active in the field. Even before its organization in 1895, however, three Academy members, Walter C. Bryant, curator of birds; Dr. Gustav Eisen, and Mr. Frank H. Vaslit, made valuable herpetological collections in Lower California, Mexico, and in Tepic, on the Mexican mainland, in the years 1889, 1890, 1892, 1893, and 1894. Also, Dr. John Van Denburgh, who later became the department's first curator, made an expedition to southern California in 1894.

Although no official herpetologist accompanied the expedition to the Revillagigedo Islands in 1903, a collection of reptiles was included in the material obtained. The spring of 1904, however, saw the first real effort at building up the Academy's herpetological collection when Dr. Van Denburgh's assistant, Mr. J. R. Slevin, gathered material in the vicinity of San Francisco and Carmel, California, while preparing for the expedition to the Galapagos Islands.

All of the collections mentioned above were destroyed in the great fire of April 18, 1906, with the exception, as already stated, of thirteen specimens saved by the curator.

Activity in the field has depended on financial conditions and the state of the world in general. The following is a chronological list of the expeditions (both before and after the organization of the department) which have resulted in notable additions to the herpetological collections of the Academy:

Year	*Collector*	*Region*
1889	Walter E. Bryant	Lower California, Mexico
1890	“	“
1892	“	“
1892	Gustav Eisen	“
1893	“	“
1894	Gustav Eisen and Frank H. Vaslit	Tepic, Mexico
1894	John Van Denburgh	Southern California
1903	Academy Expedition	Revillagigedo Islands, Mexico
1904	Joseph R. Slevin	San Francisco and Carmel, California
1905	John I. Carlson	Arizona
1905	Joseph R. Slevin	Revillagigedo Islands, Mexico, and Galapagos Islands
1906	“	Galapagos Islands
1910	John I. Carlson	Arizona
1911	Joseph R. Slevin	Coastal Regions of California, Oregon, and Washington
1912	Joseph R. Slevin and John Van Denburgh	Arizona
1913	Joseph R. Slevin	Nevada and Utah
1914	“	Tehachapi Mountains, California
1914	John I. Carlson	Arizona
1915	Joseph R. Slevin	Southern California, Nevada, and Utah
1915	“	California
1916	“	Nevada and Utah
1917	“	Southern California

Year	*Collector*	*Region*
1918	John Van Denburgh and Joseph R. Slevin	Channel Islands, California
1919	Joseph R. Slevin	Northern California and Oregon
1919	“	Cape Region, Lower California, Mexico
1920	“	Arizona
1921	“ (Academy's Gulf of California Expedition)	Gulf of California, Mexico
1922	John Van Denburgh and Joseph R. Slevin	Sierra Nevada Mountains, California
1922	Joseph R. Slevin	Guadalupe Island, Mexico
1923	John Van Denburgh and Joseph R. Slevin	San Pedro Martir Mountains, Mexico
1924	Joseph R. Slevin	Guatemala
1925	“ (Ortolan Expedition)	Revillagigedo Islands, Mexico
1926	Joseph R. Slevin	Farallon Islands, California
1926	“	Guatemala
1927	“	Southern California
1928–1929	“	Galapagos Islands
1929–1930	“	Australia
1931	“	Death Valley, California
1936–1937	“	Australia
1939	“	Panama
1940	“	Cedros Island, Lower California, Mexico
1947	Joseph R. Slevin	Arizona
1947–1948	“	Australia
1949	“	Southern California and Arizona
1951	“	Lower California, Mexico
1952	“	“
1953	Joseph R. Slevin and Walter C. Brown	Northern California
1953	Joseph R. Slevin (Orca Expedition)	Gulf of California, Mexico

Notes on the Collection

Examination of the first two volumes of the catalog of the Department of Herpetology of the Academy, which were saved by Dr. Van Denburgh just before the spread of the fire made the building untenable, reveals that the herpetological collections then contained some 8,100 specimens. Of this number only 13 were saved. These included 10 of the 15 holotypes and three additional specimens, 2 of *Plethodon intermedius* and 1 of *Pternohyla fodiens* (a topotype). The 15 holotypes in the possession of the Academy just before the advent of the earthquake and fire were:

1. *Autodax lugubris farallonensis*
2. *Chrysemys nebulosa*
3. *Eumeces lagunensis*[2]
4. *Gerrhonotus scincicauda ignavus*
5. *Lampropeltis nitida*[2]
6. *Plethodon vandykei*[2]

---

[2] Holotypes which were destroyed in 1906. In this paper neotypes are designated for *Lampropeltis nitida* (U.S.N.M. 64585), *Plethodon vandykei* (C.A.S. 47495) and *Verticaria sericea* (C.A.S. 52555). A neotype was designated for *Eumeces lagunensis* (U.S.N.M. 67398) by H. M. Smith and E. H. Taylor in 1950 (Bull. 199, U. S. Nat. Museum, p. 167).

7. *Verticaria sericea*[2]
8. *Bellophis zonatus*[2]
9. *Sceloporus becki*
10. *Sceloporus licki*
11. *Sceloporus obscurus*
12. *Uta repens*
13. *Uta stellata*
14. *Uta martinensis*
15. *Xantusia gilberti*

At the present moment (October, 1954) the collection contains approximately 76,000 catalogued specimens of reptiles and amphibians, including 171 holotypes and neotypes, and an unknown number of paratypes.[3] This collection represents the efforts of 47 years and is notable for its excellent representation of the herpetological faunas of the Galapagos Islands, western North America, Australia, Japan, Formosa (and related islands), and the Philippine Islands.

Throughout the remainder of this article the following abbreviations will be used:

C.A.S.—California Academy of Sciences, San Francisco.
S.U.—Natural History Museum of Stanford University.
U.S.N.M.—United States National Museum, Washington, D. C.
E.H.T.—Edward Harrison Taylor (private collection).
orig. no.—Original number.

Acknowledgments

The authors wish to express their gratitude to Professor George S. Myers of the Natural History Museum of Stanford University for reading and criticising the manuscript, and to Dr. Doris M. Cochran of the United States National Museum for information regarding the specimen of *Lampropeltis nitida*, which is herein designated as a neotype.

ORDER **APODA**

Family **Caeciliidae**

Ichthyophis glandulosus Taylor, 1923.

Publ.: Philip. Jour. Sci., vol. 22, no. 5, pp. 516–517.

Holotype: C.A.S. 60073 (orig. no. E.H.T. 1595A); Abungabung, Basilan Island, Philippine Islands; E. H. Taylor, October 23, 1921.

ORDER **CAUDATA**

Family **Hynobiidae**

Hynobius bicolor Dunn, 1923.

Publ.: Proc. Calif. Acad. Sci., ser. 4, vol. 12, no. 2, p. 28.

---

[2] See page 533 for footnote.

[3] Paratypes have never been designated as such in the Academy's collection of reptiles and amphibians. The authors have made no attempt to determine what paratypes may be represented, for the time alone necessary to conduct such an inquiry would itself be prohibitive.

Holotype: C.A.S. 26447; Tsushima, South Island, Korean Straits, Japan; V. Kühne, October, 1910.

Hynobius ikishimae Dunn, 1923.

Publ.: Proc. Calif. Acad. Sci., ser. 4, vol. 12, no. 2, p. 28.

Holotype: C.A.S. 26318; Iki-shima, Korean Straits, Japan; V. Kühne, October, 1910.

Hynobius retardatus Dunn 1923.

Publ.: Proc. Calif. Acad. Sci., ser. 4, vol. 12, no. 2, p. 27.

Holotype: C.A.S. 35928; Noboribetsu, Iburi Peninsula, Hokkaido, Japan; V. Kühne, August 30, 1911.

Hynobius tagoi Dunn, 1923.

Publ.: Proc. Calif. Acad. Sci., ser. 4, vol. 12, no. 2, p. 29.

Holotype: C.A.S. 26563; Tsushima, North Island, Korean Straits, Japan; V. Kühne, October, 1910.

Hynobius vanderburghii Dunn, 1923.

Publ.: Proc. Calif. Acad. Sci., ser. 4, vol. 12, no. 2, p. 28.

Holotype: C.A.S. 26714; Nara, Yamato Province, Hondo, Japan; V. Kühne, May, 1911.

Pachypalaminus boulengeri Thompson, 1912.

Publ.: Proc. Calif. Acad. Sci., ser. 4, vol. 3, pp. 184–186, pl. 14.

Holotype: C.A.S. 33192; Odaigahara Mt., Yamato Province, Honshu, Japan; V. Kühne, October, 1911.

Family **Plethodontidae**

Autodax lugubris farallonensis Van Denburgh, 1905.

Publ.: Proc. Calif. Acad. Sci., ser. 3, vol. 4, pp. 5–6.

Holotype: C.A.S. 3731; South Farallon Island; C. Fuchs, February 8, 1899.

Plethedon elongatus Van Denburgh, 1916.

Publ.: Calif. Acad. Sci., ser. 4, vol. 6, no. 7, pp. 216–218.

Holotype: C.A.S. 29096; Requa, Del Norte County, California; J. R. Slevin, May 22–26, 1911.

Plethodon vandykei Van Denburgh, 1906.

Publ.: Proc. Calif. Acad. Sci., ser. 3, vol. 4, no. 4, pp. 61–63.

Holotype: C.A.S. 6910; Paradise Valley, Mt. Rainier Park, Washington; E. C. Van Dyke, July 15–31, 1905. This specimen was destroyed in the San Francisco earthquake and fire of 1906.

Neotype: C.A.S. 47495; Forks, Clallam County, Washington; J. Van Denburgh, September 16, 1919.

ORDER **SALIENTIA**

Family **Bufonidae**

Bufo mcgregori Taylor, 1922.

Publ.: Philip. Jour. Sci., vol. 21, no. 2, pp. 182–183.

Holotype: C.A.S. 61839 (orig. no. E.H.T. 1468A); Pasananka, Zamboanga, Mindanao Island, Philippine Islands; E. H. Taylor, September 30, 1920.

Family **Hylidae**

Hyla hallowellii Thompson. 1912.

Publ.: Herpetological notices, no. 2 (Prodrome of descriptions of new reptilia and batrachia from the Far East), pp. 2–3 (privately printed: San Francisco), June 28, 1912.

Holotype: C.A.S. 23808; Kikaiga-shima, Loo Choo Islands, Japan; V. Kühne, June 21, 1909.

Hyla hallowellii Van Denburgh, 1912.

Publ.: Advance diagnoses of new reptiles and amphibians from the Loo Choo Islands and Formosa (privately printed: San Francisco), p. 3, July 29, 1912.

Holotype: C.A.S. 23806; Kikaiga-shima, Loo Choo Islands, Japan; V. Kühne, April 30, 1910.

Family **Microhylidae**

Kaloula negrosensis Taylor, 1922.

Publ.: Philip. Jour. Sci., vol. 21, no. 2, pp. 180–182.

Holotype: C.A.S. 62124 (orig. no. E.H.T. 538); Hinigaran, Negros Island, Negros Occidental Province, Philippine Islands; E. H. Taylor, April, 1915.

Kaloula rigida Taylor, 1922.

Publ.: Philip. Jour. Sci., vol. 21, no. 2, pp. 176–178.

Holotype: C.A.S. 61475 (orig. no. E.H.T. 7681); Balbalan, Kalinga Subprovince, Mountain Province, Luzon Island, Philippine Islands; E. H. Taylor, April 26, 1920.

Family **Ranidae**

Cornufer cornutus Taylor, 1922.

Publ.: Philip. Jour. Sci., vol. 21, no. 2, pp. 175–176.

Holotype: C.A.S. 61476 (orig. no. E.H.T. 764); Balbalan, Kalinga Subprovince, Mountain Province, Luzon Island, Philippine Islands; E. H. Taylor, April 24, 1920.

Cornufer montanus Taylor, 1922.

Publ.: Philip. Jour. Sci., vol. 21, no. 3, pp. 272–273, pl. 4, fig. 4.

Holotype: C.A.S. 61179 (orig. no. E.H.T. 861); Mount Banaho, Laguna Province, Luzon Island, Philippine Islands (altitude 1500 meters); E. H. Taylor, May 31, 1920.

Cornufer rivularis Taylor, 1922.

Publ.: Philip. Jour. Sci., vol. 21, no. 3, pp. 270–272, pl. 4, fig. 3.

Holotype: C.A.S. 61477 (orig. no. E.H.T. 761); Balbalan, Kalinga Subprovince, Mountain Province, Luzon Island, Philippine Islands; E. H. Taylor, April 25, 1920.

Cornufer subterrestris Taylor, 1922.

Publ.: Philip. Jour. Sci., vol. 21, no. 3, pp. 274–275.

Holotype: C.A.S. 61518 (orig. no. E.H.T. 707); along mountain trail, Mountain Province, Luzon Island, Philippine Islands; E. H. Taylor, April 17, 1920.

Micrixalus diminutiva Taylor, 1922.

Publ.: Philip. Jour. Sci., vol. 21, no. 3, pp. 267–269, pl. 1, figs. 3–4, pl. 2, figs. 2–3.

Holotype: C.A.S. 61842 (orig. no. E.H.T. 1066); Pasananka, Zamboanga, Mindanao Island, Philippine Islands; E. H. Taylor, November 10, 1920.

Philautus basilanensis Taylor, 1922.

Publ.: Philip. Jour. Sci., vol. 21, no. 2, pp. 169–171.

Holotype: C.A.S. 60145 (orig. no. E.H.T. 1510); Abungabung, Basilan Island, Philippine Islands; E. H. Taylor, October 15, 1920.

Philautus polillensis Taylor, 1922.

Publ.: Philip. Jour. Sci., vol. 21, no. 2, pp. 171–173.

Holotype: C.A.S. 62250 (orig. no. E.H.T. 351); southern end Polillo Island, Philippine Islands; E. H. Taylor, July 12, 1920.

Philautus williamsi Taylor, 1922.

Publ.: Philip. Jour. Sci., vol. 21, no. 2, pp. 167–169.

Holotype: C.A.S. 62253 (orig. no. E.H.T. 356); Polillo Island, Philippine Islands; E. H. Taylor, August 12, 1920.

Philautus zamboangensis Taylor, 1922.

Publ.: Philip. Jour. Sci., vol. 21, no. 2, pp. 173–175.

Holotype: C.A.S. 61840 (orig. no. E.H.T. 1059); Pasananka, Zamboanga, Mindanao Island, Philippine Islands; E. H. Taylor, September 26, 1920.

Rana acanthi Taylor, 1923.

Publ.: Philip. Jour. Sci., vol. 22, no. 5, pp. 523–525, pl. 2, fig. 1.

Holotype: C.A.S. 62577 (orig. no. E.H.T. 539); Busuanga, Busuanga Island, Calamian group, Philippine Islands; E. H. Taylor.

Rana igorota Taylor, 1922.

Publ.: Philip. Jour. Sci., vol. 21, no. 3, pp. 260–262, pl. 3, fig. 1.

Holotype: C.A.S. 61484 (orig. no. E.H.T. F786); Balbalan, Kalinga Subprovince, Mountain Province, Luzon Island, Philippine Islands; E. H. Taylor, April 28, 1920.

Rana merrilli Taylor, 1922.

Publ.: Philip. Jour. Sci., vol. 21, no. 2, pp. 164–166.

Holotype: C.A.S. 62448 (orig. no. E.H.T. F876); Burdeos, Polillo Island, Philippine Islands; E. H. Taylor, July 27, 1920.

Rana micrixalus Taylor, 1923.

Publ.: Philip. Jour. Sci., vol. 22, no. 5, pp. 526–527, pl. 2, figs. 2–3.

Holotype: C.A.S. 60143 (orig. no. E.H.T. 1598A); Abungabung, Basilan Island, Philippine Islands; E. H. Taylor, October 20, 1920.

Rana tafti Taylor, 1922.

Publ.: Philip. Jour. Sci., vol. 21, no. 3, pp. 265–267.

Holotype: C.A.S. 61819 (orig. no. E.H.T. 1849); mountains near the Pacific coast of Luzon, on the trail between Famy, Laguna Province, and Infanta, Tayabas Province, Luzon Island, Philippine Islands; L. H. Taft and F. X. Williams.

Rana taipehensis Van Denburgh, 1909.

Publ.: Proc. Calif. Acad. Sci., ser. 4, vol. 1, p. 56.

Holotype: C.A.S. 18007; Taipeh, Formosa; V. Kühne, March 8, 1909.

Rana woodworthi Taylor, 1923.

Publ.: Philip. Jour. Sci., vol. 22, no. 5, pp. 519–522, pl. 1, figs. 1–2.

Holotype: C.A.S. 61000 (orig. no. E.H.T. 1921); Los Banos, Laguna Province, Luzon Island, Philippine Islands; E. H. Taylor, June 12, 1921.

Rana yakani Taylor, 1922.

Publ.: Philip. Jour. Sci., vol. 21, no. 3, pp. 262–264, pl. 1, fig. 1, pl. 2, fig. 1.

Holotype: C.A.S. 60135 (orig. no. E.H.T. 1545); Abungabung, Basilan Island, Philippine Islands; E. H. Taylor, October 22, 1920.

Family **Rhacophoridae**

Polypedates linki Taylor, 1922.

Publ.: Philip. Jour. Sci., vol. 21, no. 3, pp. 276–278, pl. 3, fig. 2.

Holotype: C.A.S. 60684 (orig. no. E.H.T. 1703); Jolo, Jolo Island, Sulu Archipelago, Philippine Islands; E. H. Taylor, November 10, 1920.

ORDER **SQUAMATA**

SUBORDER **SAURIA**

Family **Agamidae**

Japalura brevipes Gressitt, 1936.

Publ.: Proc. Biol. Soc. Washington, vol. 49, pp. 117–119.

Holotype: C.A.S. 71998; Bukai, near Horisha, central Formosa (altitude 1200 meters); J. L. Gressitt (?), June 15, 1934.

Japalura polygonata ishigakiensis Van Denburgh, 1912.

Publ.: Advance diagnoses of new reptiles and amphibians from the Loo Choo Islands and Formosa (privately printed: San Francisco), p. 4, July 29, 1912.

Holotype: C.A.S. 21354; Ishigaki, Loo Choo Islands, Japan; V. Kühne, July 27, 1910.

Japalura polygonata miyakensis Van Denburgh, 1912.

Publ.: Advance diagnoses of new reptiles and amphibians from the Loo Choo Islands and Formosa (privately printed: San Francisco), p. 4, July 29, 1912.

Holotype: C.A.S. 21353; Miyako, Loo Choo Islands, Japan; V. Kühne, July 27, 1910.

Family **Amphisbaenidae**

Amphisbaena heathi Schmidt, 1936.

Publ.: Herpetologica, vol. 1, no. 1, pp. 29–30, July 11.

Holotype: C.A.S. 49374 (orig. no. S.U. 6793); Baixa Verde, Rio Grande do Norte, Brazil; J. P. Heath, May 27, 1911.

Amphisbaena slevini Schmidt, 1936.

Publ.: Herpetologica, vol. 1, no. 1, p. 31, pl. 3, fig. 3.

Holotype: C.A.S. 49809; Manaos, Grao Para, Brazil; Baker-Mann, 1911.

Amphisbaena spixi Schmidt, 1936.

Publ.: Herpetologica, vol. 1, no. 1, pp. 30–31, pl. 3, fig. 2.

Holotype: C.A.S. 49423 (orig. no. S.U. 7072); Ceara Mirim, Rio Grande do Norte, Brazil; J. P. Heath, June 23, 1911.

Leposternon polystegoides Schmidt, 1936.

Publ.: Herpetologica, vol. 1, no. 1, pp. 31–32, pl. 3, fig. 4.

Holotype: C.A.S. 49866 (orig. no. 6240); Lake Papary, Rio Grande do Norte, Brazil; Baker-Mann, 1911.

Family **Anguidae**

Celestus hancocki Slevin, 1928.

Publ.: Proc. Calif. Acad. Sci., ser. 4, vol. 16, no. 21, pp. 682–684, pl. 26.

Holotype: C.A.S. 62582; Malpelo Island (lat. 3° 59′ N., long. 81° 34′ W.); J. R. Slevin, December 20, 1927.

Family **Gekkonidae**

Coleonyx variegatus slevini Klauber, 1945.

Publ.: Trans. San Diego Soc. Nat. Hist., vol. 10, pp. 167–171.

Holotype: C.A.S. 51697; South Santa Inez Island, Gulf of California, Mexico; J. R. Slevin, May 13, 1921.

Gekko porosus Taylor, 1922.

Publ.: Philip. Jour. Sci., vol. 21, no. 2, pp. 185–187.

Holotype: C.A.S. 60526 (orig. no. E.H.T. ——); Itbayat Island, Batan Islands. Philippine Islands; G. F. Lopez, November 21, 1921.

Gekko smaragdinus Taylor, 1922.
Publ.: Philip. Jour. Sci., vol. 21, no. 2, pp. 187–190.
Holotype: C.A.S. 62336 (orig. no. E.H.T. 260); Polillo Island, Philippine Islands; E. H. Taylor, July 12, 1920.

Phyllodactylus barringtonensis Van Denburgh, 1912.
Publ.: Proc. Calif. Acad. Sci., ser. 4, vol. 1, pp. 418–420.
Holotype: C.A.S. 12057; Barrington Island, Galapagos Archipelago; J. R. Slevin, July 10, 1906.

Phyllodactylus darwini Taylor, 1942.
Publ.: Univ. Kansas Sci. Bull., vol. 28, pt. 1, no. 6, pp. 104–108, fig. 4, a–d.
Holotype: C.A.S. 10848; Chatham Island, Galapagos Archipelago; J. R. Slevin, January 27, 1906.

Phyllodactylus galapagoensis daphnensis Van Denburgh, 1912.
Publ.: Proc. Calif. Acad. Sci., ser. 4, vol. 1, p. 425.
Holotype: C.A.S. 10539; Daphne Island, Galapagos Archipelago; J. R. Slevin, November 23, 1905.

Phyllodactylus galapagoensis duncanensis Van Denburgh, 1912.
Publ.: Proc. Calif. Acad. Sci., ser. 4, vol. 1, p. 426.
Holotype: C.A.S. 10600; Duncan Island, Galapagos Archipelago; J. R. Slevin, December 9, 1905.

Family **Iguanidae**

Crotaphytus insularis Van Denburgh and Slevin, 1921.
Publ.: Proc. Calif. Acad. Sci., ser. 4, vol. 11, no. 6, pp. 95–96.
Holotype: C.A.S. 49151; east coast of Angel de la Guardia Island, 7 miles N. of Pond Island, Gulf of California, Mexico; J. R. Slevin, May 3, 1921.

Dipsosaurus carmenensis Van Denburgh, 1922.
Publ.: Occ. Pap. Calif. Acad. Sci., vol. 1, no. 10, pp. 81–82.
Holotype: C.A.S. 50504; Carmen Island, Gulf of California, Mexico; J. R. Slevin, May 21, 1921.

Dipsosaurus catalinensis Van Denburgh, 1922.
Publ.: Occ. Pap. Calif. Acad. Sci., vol. 1, no. 10, pp. 83–84.
Holotype: C.A.S. 50505; Santa Catalina Island, Gulf of California, Mexico; J. R. Slevin, June 21, 1921.

Dipsosaurus dorsalis lucasensis Van Denburgh, 1920.
Publ.: Proc. Calif. Acad. Sci., ser. 4, vol. 10, no. 4, pp. 33–34.
Holotype: C.A.S. 46090; San Jose de Cabo, Baja California, Mexico; J. R. Slevin, July 31, 1919.

Sauromalus slevini Van Denburgh, 1922.
Publ.: Occ. Pap. Calif. Acad. Sci., vol. 1, no. 10, pp. 97–99.
Holotype: C.A.S. 50503; south end of Monserrate Island, Baja California, Mexico; J. R. Slevin, May 25, 1921.

Sceloporus becki Van Denburgh, 1905.
Publ.: Proc. Calif. Acad. Sci., ser. 3, vol. 4, pp. 3, 9–10, pl. 4.
Holotype: C.A.S. 4537; San Miguel Island, Gulf of California, Mexico; R. H. Beck, May 26, 1903.

Sceloporus licki Van Denburgh, 1895.
Publ.: Proc. Calif. Acad. Sci.; ser. 2, vol. 5, pp. 110–114, pl. 10.

Holotype: C.A.S. 1436; Sierra San Lazaro, Baja California, Mexico; G. Eisen and F. Vaslit, September, 1894.

Neotype: *(Not valid.)* S.U. 2987; designated by H. Smith (1939; Proc. U.S.N.M.) to replace the C.A.S. specimen which he believed to have been lost in the earthquake and fire in San Francisco in 1906. The holotype, however, is still in existence, having been saved by Dr. Van Denburgh, and is present in the Academy's collections (see Leviton, 1953, Herpetologica, p. 128).

Sceloporus monserratensis Van Denburgh and Slevin, 1921.

Publ.: Proc. Calif. Acad. Sci., ser. 4, vol. 11, no. 17, p. 396.

Holotype: C.A.S. 50509; Monserrate Island, Gulf of California, Mexico; J. R. Slevin, May 24, 1921.

Sceloporus obscurus Van Denburgh, 1897.

Publ.: Proc. Acad. Nat. Sci. Philadelphia, p. 462.

Holotype: C.A.S. 3213; Tepic, Nayarit, Mexico; G. Eisen and F. Vaslit, November, 1894.

Sceloporus scalaris slevini Smith, 1937.

Publ.: Occ. Pap. Mus. Zool. Univ. Michigan, no. 361, pp. 3–4.

Holotype: C.A.S. 48013; Miller Peak, Huachuca Mts., Cochise Co., Arizona; J. R. Slevin, August 23, 1920.

Uma notata cowlesi Heifetz, 1941.

Publ.: Copeia, pp. 104–106, fig. 5.

Holotype: C.A.S. 53370; shores of Tepoca Bay, Sonora, Mexico; J. R. Slevin, April 25, 1921.

Uta martinensis Van Denburgh, 1905.

Publ.: Proc. Calif. Acad. Sci., ser. 3, vol. 4, pp. 18–19, pl. 6.

Holotype: C.A.S. 4698; San Martin Island, Baja California, Mexico; R. H. Beck, May 3, 1903.

Uta nolascensis Van Denburgh and Slevin, 1921.

Publ.: Proc. Calif. Acad. Sci., ser. 4, vol. 11, no. 17, pp. 395–396.

Holotype: C.A.S. 50508; San Pedro Nolasco Island, Gulf of California, Mexico; J. R. Slevin, April 17, 1921.

Uta repens Van Denburgh, 1895.

Publ.: Proc. Calif. Acad. Sci., ser. 2, vol. 5, pp. 102–104, pls. 7–8, figs. a–e.

Holotype: C.A.S. 633; Comondu, Baja California, Mexico; W. E. Bryant, April, 1889.

Uta slevini Van Denburgh, 1922.

Publ.: Occ. Pap. Calif. Acad. Sci., vol. 1, no. 10, pp. 194–196.

Holotype: C.A.S. 50506; Mejia Island, Gulf of California, Mexico; J. R. Slevin, June 28, 1921.

Uta stellata Van Denburgh, 1905.

Publ.: Proc. Calif. Acad. Sci., ser. 3, vol. 4, pp. 21–22, pl. 8.

Holotype: C.A.S. 4704; San Benito Island, Baja California, Mexico; R. H. Beck, May 6, 1903.

Family **Anguidae**

Gerrhonotus cedrosensis Fitch, 1934.

Publ.: Copeia, no. 1, pp. 6–7.

Holotype: C.A.S. 56187; canyon on southeast side of Cedros Island, Baja California, Mexico; J. R. Slevin, July 23, 1922.

Gerrhonotus scincicauda ignavus Van Denburgh, 1905.

Publ.: Proc. Calif. Acad. Sci., ser. 3, vol. 4, pp. 19–21, pl. 7, figs. 1–2.

Holotype: C.A.S. 4699; San Martin Island, Baja California, Mexico; R. H. Beck, May 3, 1903.

Family **Lacertidae**

Takydromus kuehnei Van Denburgh, 1909.

Publ.: Proc. Calif. Acad. Sci., ser. 4, vol. 3, p. 50.

Holotype: C. A. S. 18002; Kanshirei, Formosa; V. Kühne, March 27, 1909.

Takydromus sauteri Van Denburgh, 1909.

Publ.: Proc. Calif. Acad. Sci., ser. 4, vol. 3, p. 50.

Holotype: C.A.S. 18001; Koshun, Formosa; V. Kühne.

Takydromus stejnegeri Van Denburgh, 1912.

Publ.: Advance diagnoses of new reptiles and amphibians from the Loo Choo Islands and Formosa (privately printed: San Francisco), p. 8, July 29, 1912.

Holotype: C.A.S. 18417; Taipeh, Formosa; V. Kühne, March 10, 1909.

Family **Scincidae**

Eumeces barbouri Van Denburgh, 1912.

Publ.: Advance diagnoses of new reptiles and amphibians from the Loo Choo Islands and Formosa (privately printed: San Francisco), p. 4, July 29, 1912.

Holotype: C.A.S. 21545;Amami O-shima, Rio Kiu Islands, Japan; V. Kühne, April 20–30, 1910.

Eumeces chinensis formosensis Van Denburgh, 1912.

Publ.: Advance diagnoses of new reptiles and amphibians from the Loo Choo Islands and Formosa (privately printed: San Francisco), p. 6, July 29, 1912.

Holotype: C.A.S. 18605; San Shi Ka, Formosa; V. Kühne, April 14, 1909.

Eumeces gilberti rubricaudatus Taylor, 1935.

Publ.: Univ. Kansas Sci. Bull., vol. 23, pp. 446–451, figs. 72–73, pl. 39.

Holotype: C.A.S. 39002; Tehachapi Mts., Kern County, California; J. R. Slevin, April 8, 1914.

Eumeces ishigakiensis Van Denburgh, 1912.

Publ.: Advance diagnoses of new reptiles and amphibians from the Loo Choo Islands and Formosa (privately printed: San Francisco), pp. 5–6, July 29, 1912.

Holotype: C.A.S. 21666; Ishigaki-shima, Loo Choo Islands, Japan; V. Kühne, May 25–June 2, 1910.

Eumeces lagunensis Van Denburgh, 1895.

Publ.: Proc. Calif. Acad. Sci., ser. 2, vol. 5, pp. 79, 134–135, pl. 13.

Holotype: C.A.S. 400 and 402 (Syntypes; San Francisquito, Sierra Laguna, Baja California, Mexico; G. Eisen, March 28, 1892. These specimens were lost during the earthquake and fire in San Francisco, 1906.

Neotype: U.S.N.M. 67398 (Smith, H. M., and Taylor, E. H., Bull. 199, U.S. Nat. Mus., pp. 167–168, 1950); San Francisquito, Sierra de la Laguna, Baja California, Mexico.

Eumeces marginatus amamiensis Van Denburgh, 1912.

Publ.: Advance diagnoses of new reptiles and amphibians from the Loo Choo Islands and Formosa (privately printed: San Francisco), pp. 4–5, July 29, 1912.

Holotype: C.A.S. 21615; Amami O-shima, Loo Choo Islands, Japan; V. Kühne, April 26–May 1, 1910.

Eumeces marginatus kikaigensis Van Denburgh, 1912.

Publ.: Advance diagnoses of new reptiles and amphibians from the Loo Choo Islands and Formosa (privately printed: San Francisco), p. 5, July 29, 1912.

Holotype: C.A.S. 21628; Kikaiga-shima, Loo Choo Islands, Japan; V. Kühne, April 30, 1910.

Eumeces oshimensis Thompson, 1912.

Publ.: Herpetological notices, no. 2, p. 4 (Prodrome of descriptions of new species of reptilia and batrachia from the Far East), June 28, 1912 (privately printed: San Francisco).

Holotype: C.A.S. 21729: Kikaiga-shima, Loo Choo Islands, Japan; V. Kühne, April 30, 1910.

Eumeces stimsonii Thompson, 1912.

Publ.: Herpetological notices, no. 2 (Prodrome of descriptions of new species of reptilia and batrachia from the Far East), p. 4, June 28, 1912 (privately printed: San Francisco).

Holotype: C.A.S. 21645; Ishigaki Island, Loo Choo Islands, Japan; V. Kühne, May 25–June 2, 1910.

Leiolopisma laterale boettgeri Van Denburgh, 1912.

Publ.: Advance diagnoses of new reptiles and amphibians from the Loo Choo Islands and Formosa (privately printed: San Francisco), p. 7, July 29, 1912.

Holotype: C.A.S. 21678; Ishigaki-shima, Loo Choo Islands, Japan; V. Kühne, May 25--June 2, 1910.

Leiolopisma laterale formosensis Van Denburgh, 1912.

Publ.: Advance diagnoses of new reptiles and amphibians from the Loo Choo Islands and Formosa (privately printed: San Francisco), p. 7, July 29, 1912.

Holotype: C.A.S. 25027; Kanshirei, Formosa; V. Kühne, March 20, 1909.

Lygosoma incognita Thompson, 1912.

Publ.: Herpetological notices, no. 2 (Prodrome of descriptions of new species of reptilia and batrachia from the Far East), pp. 3–4, June 28, 1912 (privately printed: San Francisco).

Holotype: C.A.S. 18700; Koshun, Formosa; V. Kühne, March, 1909.

Lygosoma formosensis Thompson, 1912.

Publ.: Herpetological notices, no. 2 (Prodrome of descriptions of new species of reptilia and batrachia from the Far East), p. 3, June 28, 1912 (privately printed: San Francisco).

Holotype: C.A.S. 18627; Kanshirei, Formosa; V. Kühne, March, 1909.

Lygosoma laterale formosensis Thompson, 1912.

Publ.: Herpetological notices, no. 3 (On reptiles new to the island arcs of Asia), p. 2, July 31, 1912 (privately printed: San Francisco).

Holotype: C.A.S. 25026; Kanshirei, Formosa; V. Kühne, March, 1909.

Lygosoma laterale ishigakiensis Thompson, 1912.

Publ.: Herpetological notices, no. 3 (On reptiles new to the island arcs of Asia), p. 2, July 31, 1912 (privately printed: San Francisco).

Holotype: C.A.S. 21677; Ishigaki Island, Loo Choo Island, Japan; V. Kühne, May, 1910. Its present whereabouts is unknown.

Lygosoma okinavensis Thompson, 1912.

Publ.: Herpetological notices, no. 2 (Prodrome of descriptions of new species of reptilia and batrachia from the Far East), p. 4, June 28, 1912 (privately printed: San Francisco).

Holotype: C.A.S. 21537; Okinawa Island, Loo Choo Islands, Japan; V. Kühne, May, 1910.

Lygosaurus pellopleurus browni Van Denburgh, 1912.

Publ.: Advance diagnoses of new reptiles and amphibians from the Loo Choo Islands and Formosa (privately printed: San Francisco), p. 7, July 29, 1912.

Holotype, C.A.S. 21408; Amami O-shima, Loo Choo Islands, Japan; V. Kühne, April 26–May 1, 1910.

Mabuya bontocensis Taylor, 1923.

Publ.: Philip. Jour. Sci., vol. 22, no. 5, pp. 532–534.

Holotype: C.A.S. 61331 (orig. no. E.H.T. 696); along mountain trail, Bontoc Subprovince, Mountain Province, Luzon Island, Philippine Islands; E. H. Taylor, April, 1920.

Mabuya heathi Schmidt and Inger, 1951.

Publ.: Chicago Mus. (Field Mus. Nat. Hist.), Zool. Ser., publ. no. 661.

Holotype: C.A.S. 49599 (orig. no. S.U. 6788); Fortaleza, Brazil; J. Health, 1911.

Siaphos herrei Taylor, 1922.

Publ.: Philip. Jour. Sci., vol. 21, no. 2, pp. 194–196.

Holotype: C.A.S. 62262 (orig. no. E.H.T. 208); Polillo Island, Philippine Islands; E. H. Taylor, July, 1920.

Sphenomorphus bakeri Taylor, 1922.

Publ.: Philip. Jour. Sci., vol. 21, no. 2, pp. 193–194.

Holotype: C.A.S. 61330 (orig. no. E.H.T. ——); Haight's place, Pauai, Benguet, Mountain Province, Luzon Island, Philippine Islands; C. F. Baker, April, 1921.

Sphenomorphus beyeri Taylor, 1922.

Publ.: Philip. Jour. Sci., vol. 21, no. 3, pp. 283–285.

Holotype: C.A.S. 61183 (orig. no. E.H.T. 17); Mount Banahao, Laguna Province, Luzon Island, Philippine Islands; E. H. Taylor, May 31, 1920.

Sphenomorphus boulengeri Van Denburgh, 1912.

Publ.: Advance diagnoses of new reptiles and amphibians from the Loo Choo Islands and Formosa (privately printed: San Francisco), pp. 6–7, July 29, 1912.

Holotype: C.A.S. 18700; Koshun, Formosa; V. Kühne, March 14, 1909.

Sphenomorphus indicus formosensis Van Denburgh, 1912.

Publ.: Advance diagnoses of new reptiles and amphibians from the Loo Choo Islands and Formosa (privately printed: San Francisco), p. 6, July 29, 1912.

Holotype: C.A.S. 18622; Kanshirei, Formosa; V. Kühne, March 24, 1909.

Sphenomorphus stejnegeri Taylor, 1923.

Publ.: Philip. Jour. Sci., vol. 22, no. 5, pp. 537–538.

Holotype: C.A.S. 61182 (orig. no. E.H.T. 16); Mount Banahao, Laguna Province, Luzon Island, Philippine Islands; E. H. Taylor, May 30, 1920.

Tropidophorus stejnegeri Taylor, 1922.

Publ.: Philip. Jour. Sci., vol. 21, no. 3, pp. 285–287, pl. 4, fig. 1.

Holotype: C.A.S. 60230 (orig. no. E.H.T. 1538); Abungabung, Basilan Island, Philippine Islands; E. H. Taylor, October 22, 1920.

Family **Teiidae**

Cnemidophorus arizonae Van Denburgh, 1896.

Publ.: Proc. Calif. Acad. Sci., ser. 2, vol. 6, pp. 344–346, pl. 49.

Holotype: S.U. 2631; Fairbank, Cochise County, Arizona; W. W. Price, May 13,

1894. This specimen has been returned to Stanford University (see Leviton, 1953, Herpetologica, p. 129).

Cnemidophorus bacatus Van Denburgh and Slevin, 1921.
Publ.: Proc. Calif. Acad. Sci., ser. 4, vol. 11, no. 6, p. 97.
Holotype: C.A.S. 49152; San Pedro Nolasco Island, Gulf of California, Mexico; J. R. Slevin, April 17, 1921.

Cnemidophorus canus Van Denburgh and Slevin, 1921.
Publ.: Proc. Calif. Acad. Sci., ser. 4, vol. 11, no. 6, p. 97.
Holotype: C.A.S. 49153; Sal Si Puedes Island, Gulf of California, Mexico; J. R. Slevin, May 9, 1921.

Cnemidophorus catalinensis Van Denburgh and Slevin, 1921.
Publ.: Proc. Calif. Acad. Sci., ser. 4, vol. 11, no. 17, p. 396.
Holotype: C.A.S. 50507; Santa Catalina Island, Gulf of California, Mexico; J. R. Slevin, June 12, 1921.

Cnemidophorus dickersonae Van Denburgh and Slevin, 1921.
Publ.: Proc. Calif. Acad. Sci., ser. 4, vol. 11, no. 6, pp. 97–98.
Holotype: C.A.S. 49154; Isla Partida, near Angel de la Guardia Island, Gulf of California; Mexico; J. R. Slevin, April 22, 1921.

Verticaria ceralbensis Van Denburgh and Slevin, 1921.
Publ.: Proc. Calif. Acad. Sci., ser. 4, vol. 11, no. 17, p. 396.
Holotype: C.A.S. 50510; Ceralbo Island, Gulf of California, Mexico; J. R. Slevin, June 6, 1921.

Verticaria espiritensis Van Denburgh and Slevin, 1921.
Publ.: Proc. Calif. Acad. Sci., ser. 4, vol. 11, no. 17, p. 397.
Holotype: C.A.S. 50511; Espiritu Santo Island, Gulf of California, Mexico; J. R. Slevin, June 1, 1921.

Verticaria franciscensis Van Denburgh and Slevin, 1921.
Publ.: Proc. Calif. Acad. Sci., ser. 4, vol. 11, no. 17, p. 397.
Holotype: C.A.S. 50513; San Francisco Island, Gulf of California, Mexico; J. R Slevin, May 30, 1921.

Verticaria hyperythrus danheimae Burt, 1929.
Publ.: Proc. Biol. Soc. Washington, vol. 12, pp. 154–156.
Holotype: C.A.S. 435 (new name for *Verticaria sericea* Van Denburgh. The holotype of this species was lost in 1906. Refer to *V. sericea* for designation of neotype).

Verticaria hyperythrus schmidti Van Denburgh, 1921.
Publ.: Proc. Calif. Acad. Sci., ser. 4, vol. 11, no. 17, p. 397.
Holotype: C.A.S. 50512; San Marcos Island, Gulf of California, Mexico; J. R. Slevin, May 12, 1921.

Verticaria picta Van Denburgh and Slevin, 1921.
Publ.: Proc. Calif. Acad. Sci., ser. 4, vol. 11, no. 6, p. 98.
Holotype: C.A.S. 49155; Monserrate Island, Gulf of California, Mexico; J. R. Slevin, May 25, 1921.

Verticaria sericea Van Denburgh, 1895.
Publ.: Proc. Calif. Acad. Sci., ser. 2, vol. 5, pp. 132–133, pl. 12.
Holotype: C.A.S. 435; San Jose Island, Gulf of California, Mexico; W. E. Bryant, April, 1892. This specimen was lost in the earthquake and fire in San Francisco, 1906.
Neotype: C.A.S. 52555; San Jose Island, Gulf of California, Mexico; J. R. Slevin,

May 28, 1921. This specimen stands as the type of *V. hyperythrus danheimae* Burt, a substitute name for *V. sericea* (see Burt, Proc. Biol. Soc. Wash., vol. 12, pp. 154–156, 1929).

Family **Xantusiidae**

Xantusia gilberti Van Denburgh, 1895.

Publ.: Proc. Calif. Acad. Sci., ser. 2, vol. 4, pp. 121–122, pl. 11.

Holotype: C.A.S. 401; San Francisquito, Sierra Laguna, Lower California, Mexico; G. Eisen, March 28, 1892.

SUBORDER **SERPENTES**

Family **Amblycephalidae**

Amblycephalus formosensis Van Denburgh, 1909.

Publ.: Proc. Calif. Acad. Sci., ser. 4, vol. 3, p. 55.

Holotype: C.A.S. 18006; Kanshirei, Formosa; V. Kühne, March 27, 1909.

Family **Boidae**

Charina bottae utahensis Van Denburgh, 1920.

Publ.: Proc. Calif. Acad. Sci., ser. 4, vol. 10, no. 3, pp. 31–32.

Holotype: C.A.S. 38421; Little Cottonwood Canyon, Wasatch Mts., Wasatch County, Utah; J. R. Slevin, June 28, 1913.

Family **Colubridae**

Achalinus loochooensis Thompson, 1912.

Publ.: Herpetological notices, no. 3 (On reptiles new to the island arcs of Asia), p. 3, July 31, 1912 (privately printed: San Francisco).

Holotype: C.A.S. 22064; Amami O-shima, Loo Choo Islands, Japan; V. Kühne, April 26–May 1, 1910.

Achalinus werneri Van Denburgh, 1912.

Publ.: Advance diagnoses of new reptiles and amphibians from the Loo Choo Islands and Formosa (privately printed: San Francisco), p. 8, July 29, 1912.

Holotype: C.A.S. 22064; Nase, Amami O-shima, Loo Choo Islands, Japan; V. Kühne, April 26–May 1, 1910.

Bellophis zonatus Lockington, 1877.

Publ.: Proc. Calif. Acad. Sci., ser. 1, vol. 7, pp. 52–53.

Syntypes: C.A.S. 334–335; Santa Barbara, California; Paymaster Stanton, U.S.N.

This name was published as a new genus and a new species, but Lockington was not sure whether his snake was specifically identical with *Coluber zonatus* Blainville, and specifically states, "I have preserved (Blainville's) specific name of *zonatus*." The specimens of *B. zonatus* Lockington had been entered in the reptile register books of the Academy but had not been indicated as types. These specimens were destroyed in the 1906 fire, as recorded by Van Denburgh in a letter to Blanchard (1921:222, in footnote).

There is some discrepancy in locality data. Although Lockington states that the specimens came from "Northern California," they are recorded in the Academy's catalogues as being collected at Santa Barbara. Zweifel (Copeia, 1952:156) examined this problem and came to the conclusion that Lockington's published data is probably correct. The authors have listed Santa Barbara above since it is so recorded in the catalogues.

Calamaria hollandi Taylor, 1923.

Publ.: Philip. Jour. Sci., vol. 22, no. 5, pp. 550–552.

Holotype: C.A.S. 60471 (orig. no. E.H.T. 1255); Port Holland, Basilan Island, Philippine Islands; E. H. Taylor, October, 1920.

Calamaria joloensis Taylor, 1922.

Publ.: Philip. Jour. Sci., vol. 21, no. 2, pp. 203–204.

Holotype: C.A.S. 60901 (orig. no. E.H.T. 1855); central Jolo Island, Sulu Archipelago, Philippine Islands; E. H. Taylor, October 30, 1920.

Calamaria polillensis Taylor, 1923.

Publ.: Philip. Jour. Sci., vol. 22, no. 5, pp. 549–550.

Holotype: C.A.S. 62455 (orig. no. E.H.T. 341A); Polillo, Polillo Island, Philippine Islands; E. H. Taylor, July, 1921.

Calamaria tropica Taylor, 1922.

Publ.: Snakes of the Philip. Islands, Philip. Bureau Sci., Manila; pp. 194–195.

Holotype: C.A.S. 62069 (orig. no. E.H.T. 887); low coastal mountains, near Naujan, Mindoro Island, Philippine Islands; E. H. Taylor, May 2, 1916.

Chilomeniscus punctatissimus Van Denburgh and Slevin, 1921.

Publ.: Proc. Calif. Acad. Sci., ser. 4, vol. 11, no. 6, p. 98.

Holotype: C.A.S. 49156; Isla Partida-Espiritu Santo Island, Gulf of California, Mexico; J. C. Chamberlin, May 31, 1921.

Chionactis occipitalis talpina Klauber, 1951.

Publ.: Trans. San Diego Soc. Nat. Hist., vol. 11, no. 9, pp. 172–175, pl. 10, fig. 1.

Holotype: C.A.S. 81364; 50 mi. S. Goldfield, on the highway to Beatty, Nye County, Nevada; J. R. Slevin and W. Wood, June 3, 1947.

Coluber barbouri Van Denburgh and Slevin, 1921.

Publ.: Proc. Calif. Acad. Sci., ser. 4, vol. 11, no. 6, p. 98.

Holotype: C.A.S. 49157; Isla Partida-Espiritu Santo Island, Gulf of California, Mexico; J. R. Slevin, May 30, 1921.

Cyclocorus nuchalis Taylor, 1923.

Publ.: Philip. Jour. Sci., vol. 22, no. 5, pp. 543–545, pl. 3, figs. 1–2.

Holotype: C.A.S. 62558 (orig. no. E.H.T. 1428); Pasananka, Zamboanga, Mindanao Island, Philippine Islands; E. H. Taylor, September 30, 1920.

Diadophis amabilis vandenburghi Blanchard, 1923.

Publ. Occ. Pap. Mus. Zool. Univ. Mich., no. 142, pp. 5–6, 8.

Holotype: C.A.S. 13748, collected by J. R. Slevin, June 20, 1907; Carmel, Monterey County, California.

Diadophis anthonyi Van Denburgh and Slevin, 1923.

Publ.: Proc. Calif. Acad. Sci., ser. 4, vol. 13, no. 1, p. 1.

Holotype: C.A.S. 56766; South Todos Santos Island, Baja California, Mexico.

Dromicus hoodensis Van Denburgh, 1912.

Publ.: Proc. Calif. Acad. Sci., ser. 4, vol. 1, pp. 338–341, pl. 24.

Holotype: C.A.S. 11799; Hood Island, Galapagos Archipelago; J. R. Slevin, June 23, 1906.

Dromicus occidentalis Van Denburgh, 1912.

Publ.: Proc. Calif. Acad. Sci., ser. 4, vol. 1, pp. 347–349, pl. 27.

Holotype: C.A.S. 11488; Narborough Island, Galapagos Archipelago; J. R. Slevin, April 18, 1906.

Dromicus occidentalis helleri Van Denburgh, 1912.
Publ.: Proc. Calif. Acad. Sci., ser. 4, vol. 1, pp. 349–351, pl. 28.
Holotype: C.A.S. 10280; Brattle Island, Galapagos Archipelago; J. R. Slevin, October 30, 1905.

Dromicus slevini Van Denburgh, 1912.
Publ.: Proc. Calif. Acad. Sci., ser. 4, vol. 1, pp. 351–353, pl. 29.
Holotype: C.A.S. 12216; Duncan Island, Galapagos Archipelago; J. R. Slevin, August 14, 1906.

Dromicus steindachneri Van Denburgh, 1912.
Publ.: Proc. Calif. Acad. Sci., ser. 4, vol. 1, pp. 353–355, pl. 30.
Holotype: C.A.S. 10795; Indefatigable Island, Galapagos Archipelago; J. R. Slevin, January 16, 1906.

Dryocalamus mccroryi Taylor, 1922.
Publ.: Philip. Jour. Sci., vol. 21, no. 2, pp. 197–199.
Holotype: C.A.S. 60346 (orig. no. E.H.T. 1517); Abungabung, Basilan Island, Philippine Islands; E. H. Taylor, October 23, 1920.

Eudryas slevini Stuart, 1933.
Publ.: Occ. Pap. Mus. Zool. Univ. Michigan, no. 254, pp. 9–10.
Holotype: C.A.S. 58679; Maria Madre Island, Las Tres Marias Islands, Mexico; J. R. Slevin, May 17, 1925.

Hydromorphus dunni Slevin, 1942.
Publ.: Proc. Calif. Acad. Sci., ser. 4, vol. 23, no. 32, p. 474.
Holotype: C.A.S. 78939; vicinity N. of Boquete, Chiriquí Province, Panama; J. R. Slevin, July 30, 1939.

Hypsiglena ochrorhynchus tortugaensis Tanner (W.W.), 1944.
Publ.: The Great Basin Naturalist, vol. 5, nos. 3 and 4, pp. 69–71.
Holotype: C.A.S. 51460; Tortuga Island, Gulf of California, Mexico; J. R. Slevin, June 22, 1921.

Hypsiglena slevini Tanner (W.W.), 1943.
Publ.: The Great Basin Naturalist, vol. 4, pp. 53–54.
Holotype: C.A.S. 53631; Puerto Escondido, Baja California, Mexico; J. R. Slevin, June 14, 1921.

Hypsiglena torquata gularis Tanner (W.W.), 1954.
Publ.: Herpetologica, vol. 10, part 1, pp. 54–56.
Holotype: C.A.S. 51010; Isla Partida, Baja California, Mexico; J. R. Slevin, April 22, 1921.

Lampropeltis agalma Van Denburgh and Slevin, 1923.
Publ.: Proc. Calif. Acad. Sci., ser. 4, vol. 13, p. 2.
Holotype: C.A.S. 56865; Alcatraz, San Pedro Martir Mts., Baja California, Mexico; Expedition to Southern and Lower California, June 16, 1923.

Lampropeltis catalinensis Van Denburgh and Slevin, 1921.
Publ.: Proc. Calif. Acad. Sci., ser. 4, vol. 11, no. 17, pp. 397–398.
Holotype: C.A.S. 50514; Santa Catalina Island, Gulf of California, Mexico; J. R. Slevin, June 12, 1921.

Lampropeltis herrerae Van Denburgh and Slevin, 1923.
Publ.: Proc. Calif. Acad. Sci., ser. 4, vol. 13, p. 2.
Holotype: C.A.S. 56755; South Todos Santos Island, Baja California, Mexico; Expedition to Southern and Lower California, July 10, 1923.

Lampropeltis nitida Van Denburgh, 1895.

Publ.: Proc. Calif. Acad. Sci., ser. 2, vol. 3, pp. 143–144, pl. 14.

Holotype: C.A.S. 800; San Jose del Cabo, Baja California, Mexico; G. Eisen, September, 1893. This specimen was lost in the earthquake and fire in San Francisco, 1906.

Neotype: U.S.N.M. 64585; Miraflores, Baja California, Mexico; C. H. Townsend, May, 1911. (This specimen was formerly in the collections of the American Museum of Natural History, number 5648.)

Lycodon subcinctus sealei Leviton, 1955.

Publ.: Philip. Jour. Sci., vol. 84, no. 2, pp. 195–198.

Holotype: C.A.S. 15819; Puerto Princesa, Palawan Island, Philippine Islands; A. Seale, February 20, 1908.

Natrix barbouri Taylor, 1922.

Publ.: Philip. Jour. Sci., vol. 21, no. 3, pp. 291–293.

Holotype: C.A.S. 61552 (orig. no. E.H.T. 939); Balbalan, Kalinga Subprovince, Luzon Island, Philippine Islands; E. H. Taylor, April 26, 1920.

Natrix copei Van Denburgh, 1909.

Publ.: Proc. Calif. Acad. Sci., ser. 4, vol. 3, pp. 52–53.

Holotype: C.A.S. 18004; Kanshirei, Formosa, V. Kühne, March 24, 1909.

Natrix vibakari ruthveni Van Denburgh, 1923.

Publ.: Proc. Calif. Acad. Sci., ser. 4, vol. 13, no. 2, pp. 3–4.

Holotype: C.A.S. 31487; Fusan, Kjong-Sang-Do Province, Korea; V. Kühne, May 8, 1911.

Oligodon iwahigensis Griffin, 1909.

Publ.: Philip. Jour. Sci., vol. 8, p. 598.

Holotype: Bureau Sci. Manila R 16; Iwahig, Palawan Island, Philippine Islands. This specimen appears to have been destroyed during World War II in the fire which consumed the Bureau of Science building in Manila.

Neotype: C.A.S. 62173 (orig. no. Bureau of Science R 923); Iwahig, Palawan Island, Philippine Islands; E. H. Taylor.

Oligodon ornatus Van Denburgh, 1909.

Publ.: Proc. Calif. Acad. Sci., ser. 4, vol. 3, pp. 53–54.

Holotype: C.A.S. 18005; Shinchiku, Formosa; V. Kühne, March 7, 1909.

Pituophis catenifer insularis Klauber, 1946.

Publ.: Trans. San Diego Soc. Nat. Hist., vol. 11, no. 1, pp. 11–14, pl. 1, fig. 1.

Holotype: C.A.S. 56353; Cedros Island, off west coast of Baja California, Mexico; J. R. Slevin, August 7, 1922.

Pituophis catenifer rutilus Van Denburgh, 1920.

Publ.: Proc. Calif. Acad. Sci., ser. 4, vol. 10, pp. 24–27, pl. 2, fig. 2.

Holotype: C.A.S. 33869; Tucson, Pima County, Arizona; J. R. Slevin, April 11, 1912.

Pituophis catenifer stejnegeri Van Denburgh, 1920.

Publ.: Proc. Calif. Acad. Sci., ser. 4, vol. 10, pp. 21–24, pl. 21, fig. 1.

Holotype: C.A.S. 14203; Fort Douglas, Salt Lake County, Utah; J. C. Clemens, June-July, 1908.

Pseudagkistrodon carinatus Van Denburgh, 1909.

Publ.: Proc. Calif. Acad. Sci., ser. 4, vol. 3, pp. 51–52.

Holotype: C.A.S. 18003; Formosa; V. Kühne, March 27, 1909.

Pseudorhabdium minutum Taylor, 1922.

Publ.: Philip. Jour. Sci., vol. 21, no. 2, pp. 200–202.

Holotype: C.A.S. 61544 (orig. no. E.H.T. F772); Balbalan, Kalinga Subprovince, Mountain Province, Luzon Island, Philippine Islands; E. H. Taylor, April 25, 1920.

Pseudoxenodon popei Gressitt, 1936.

Publ.: Proc. Biol. Soc. Washington, vol. 49, pp. 119–121.

Holotype: C.A.S. 71997; Loi Mother Mts., altitude 1450 meters, central part of Hainan Island; J. L. Gressitt, July 26, 1935.

Tantilla nelsoni Slevin, 1926.

Publ.: Proc. Calif. Acad. Sci., ser. 4, vol. 15, pp. 200–201.

Holotype: C.A.S. 58680; Maria Madre Island, Tres Marias Islands, Mexico. This specimen was lost while on transit in the mails.

Tantilla utahensis Blanchard, 1938.

Publ.: Field Mus. Nat. Hist., Zool. Ser., vol. 20, no. 28, pp. 372–373.

Holotype: C.A.S. 55214; St. George, Washington County, Utah; V. M. Tanner.

Thamnophis ordinoides hueyi Van Denburgh and Slevin, 1923.

Publ.: Proc. Calif. Acad. Sci., ser. 4, vol. 13, p. 2.

Holotype: C.A.S. 56855; Arroyo Encantada, between La Grulla and La Encantada, Sierra San Pedro Martir, northern Baja California, Mexico; Expedition to Southern and Lower California, June 13–15, 1923.

Trimetopon posadasi Slevin, 1936.

Publ.: Proc. Calif. Acad. Sci., ser. 4, vol. 23, no. 4, pp. 79–81.

Holotype: C.A.S. 66964; southern slope Volcan Zunil, Suchitepequez, Guatemala; J. R. Slevin, August 8, 1924.

Trimetopon slevini Dunn, 1940.

Publ.: Proc. Acad. Nat. Sci. Phili., vol. 92, pp. 117–118.

Holotype: C.A.S. 78938, Boquete, Panama; J. R. Slevin, July 20, 1939.

Trimorphodon vandenburghi Klauber, 1924.

Publ.: Bull. Zool. Soc. San Diego, no. 1, p. 17.

Holotype: C.A.S. 58172; Wildwood ranch, alt. 1520 ft., 5 mi. SW of Ramona, San Diego County, California; E. Woodworth and L. M. Klauber, May 4, 1924.

Typhlogeophis ater Taylor, 1922.

Publ.: Philip. Jour. Sci., vol. 21, no. 2, pp. 202–203.

Holotype: C.A.S. 62043 (orig. no. E.H.T. 1103); Pasananka, Zamboanga, Mindanao Island, Philippine Islands; E. H. Taylor, September 28, 1920.

Family **Crotalidae**

Crotalus lucasensis Van Denburgh, 1920.

Publ.: Proc. Calif. Acad. Sci., ser. 4, vol. 10, no. 2, pp. 29–30, pl. 3.

Holotype: C.A.S. 45888; Agua Caliente, Cape region of Baja California, Mexico; J. R. Slevin, July 26, 1919.

Crotalus tortugensis Van Denburgh and Slevin, 1921.

Publ.: Proc. Calif. Acad. Sci., ser. 4, vol. 11, no. 17, p. 398.

Holotype: C.A.S. 50515; Tortuga Island, Gulf of California, Mexico; J. R. Slevin, June 22, 1921.

Family **Elapidae**

Callophis formosensis Thompson, 1912.

Publ.: Herpetological notices, no. 3 (On reptiles new to the island arcs of Asia), p. 4, July 31, 1912 (privately printed: San Francisco).

Holotype: C.A.S. 18864, Kosempo, Formosa; V. Kühne, March 14, 1909. Its present whereabouts is unknown.

Callophis swinhoei Van Denburgh, 1912.

Publ.: Advance diagnoses of new reptiles and amphibians from the Loo Choo Islands and Formosa (privately printed: San Francisco), p. 8, July 29, 1912.

Holotype: C.A.S. 14978; Suisahako, central Formosa; V. Kühne, October 5, 1907.

Glyphodon barnardi Kinghorn, 1939.

Publ.: Rec. Aust. Mus., vol. 20, no. 4, p. 258.

Holotype: C.A.S. 77798; 15 miles S. Duaringa, Queensland, Australia; C. Barnard, 1936.

Micrurus nigrocinctus zunilensis Schmidt, 1932.

Publ.: Proc. Calif. Acad. Sci., ser. 4, vol. 20, pp. 263–267.

Holotype:C.A.S. 66001; Finca El Cipres, Volcan Zunil, Suchitepequez, Guatemala; J. R. Slevin, June 1, 1926.

Family **Hydrophidae**

Disteira cincinnatii Van Denburgh and Thompson, 1908.

Publ.: Proc. Calif. Acad. Sci., ser. 4, vol. 3, pp. 41–48, pl. 7.

Holotype: C.A.S. 15016; one mile NE Cavite, Manila Bay, Luzon Island, Philippine Islands; J. C. Thompson, December 20, 1906.

Laticauda crockeri Slevin, 1934.

Publ.: Proc. Calif. Acad. Sci., ser. 4, vol. 21, no. 15, pp. 186–187.

Holotype: C.A.S. 72001; Lake Tungano, Rennell Island, Solomon Islands; crew of the "Zaca," June 8, 1933.

Family **Leptotyphlopidae**

Leptotyphlops humilis slevini Klauber, 1931.

Publ.: Trans. San Diego Soc. Nat. Hist., vol. 6, no. 23, pp. 338–339.

Holotype: C.A.S. 53721; La Paz, Baja California, Mexico; J. R. Slevin, June 2, 1921.

Leptotyphlops subcrotilla Klauber, 1939.

Publ.: Trans. San Diego Soc. Nat. Hist., vol. 9, no. 14, pp. 61–62, figs. 2a–2b.

Holotype: C.A.S. 14554; Grau Tombes, northern Peru; G. Baer, 1902.

ORDER **TESTUDINATA**

Family **Emyidae**

Chrysemys nebulosa Van Denburgh, 1895.

Publ.: Proc. Calif. Acad. Sci., ser. 2, vol. 5, pp. 84–85, pls. 4–6.

Holotype: C.A.S. 2244; mainland abreast of San Jose Island, Baja California, Mexico; W. E. Bryant.

Family **Testudinidae**

Testudo chatamensis Van Denburgh, 1907.

Publ.: Proc. Calif. Acad. Sci., ser. 4, vol. 1, p. 4.

Holotype: C.A.S. 8127; Chatham Island, Galapagos Archipelago; R. H. Beck and J. R. Slevin, February 12–14, 1906.

Testudo darwini Van Denburgh, 1907.

Publ.: Proc. Calif. Acad. Sci., ser. 4, vol. 1, p. 4.

Holotype: C.A.S. 8108; James Island, Galapagos Archipelago; R. H. Beck and J. R. Slevin, July 31, 1906.

Testudo hoodensis Van Denburgh, 1907.

Publ.: Proc. Calif. Acad. Sci., ser. 4, vol. 1, p. 3.

Holotype: C.A.S. 8121; Hood Island, Galapagos Archipelago; J. R. Slevin and E. S. King, June 27, 1906.

Testudo phantasticus Van Denburgh, 1907.

Publ.: Proc. Calif. Acad. Sci., ser. 4, vol. 1, p. 4.

Holotype: C.A.S. 8101; Narborough Island, Galapagos Archipelago; R. H. Beck, April 5, 1906.

Testudo vandenburghi De Sola, 1930.

Publ.: Copeia, 1930, no. 3, pp. 79–80 (see also Van Denburgh, Proc. Calif. Acad. Sci., ser. 4, vol. 2, pt. 1, pp. 362–365, pls. 122–123, 1914).

Holotype: C.A.S. 8141; Cowley Mt., Albemarle Island, Galapagos Archipelago; R. H. Beck, August 10–11, 1906.

BIBLIOGRAPHY OF JOHN VAN DENBURGH

(1872–1924)

Curator of Herpetology, California Academy of Sciences 1895–1924

1. 1888. Two large sets of quail eggs. *The Oologist*, vol. 5, nos. 10–11, p. 156, October–November.
2. 1891. Anna's hummingbird. *The Bittern*, vol. 1, no. 6, p. 3, April–May.
3. 1894. Annotated list of reptiles and batrachians. In: Report of the Commissioner of Fish and Fisheries on Investigations in the Columbia River Basin in regard to the Salmon Fisheries. Washington, D.C., pp. 56–57.
4. —— Descriptions of three new lizards from California and Lower California, with a note on *Phrynosoma blainvillii. Proceedings of the California Academy of Sciences*, ser. 2, vol. 4, pp. 296–301, July 12.
5. —— Notes on "*Crotalus mitchellii* and *Crotalus pyrrhus*." *Proceedings of the California Academy of Sciences*, ser. 2, vol. 4, pp. 450–455, September 25.
6. —— *Phrynosoma solaris*, with a note on its distribution. *Proceedings of the California Academy of Sciences*, ser. 2, vol. 4, p. 456, September 25.
7. 1895. A review of the herpetology of Lower California. Part I. Reptiles. *Proceedings of the California Academy of Sciences*, ser. 2, vol. 5, pp. 77–162, pls. 4–14, May 28.
8. —— The species of the genus *Xantusia*. *Proceedings of the California Academy of Sciences*, ser. 2, vol. 5, pp. 523–534, August 28.
9. —— A review of the herpetology of Lower California. Part II. Batrachians. *Proceedings of the California Academy of Sciences*, ser. 2, vol. 5, pp. 556–561, September 10.
10. —— Notes on the habits and distribution of *Autodax iëcanus*. *Proceedings of the California Academy of Sciences*, ser. 2, vol. 5, pp. 776–778, October 30.
11. 1895. Description of a new rattlesnake *(Crotalus pricei)* from Arizona. *Proceedings of the California Academy of Sciences*, ser. 2, vol. 5, pp. 856–857, December 30.
12. 1896. Additional notes on the herpetology of Lower California. *Proceedings of the California Academy of Sciences*, ser. 2, vol. 5, pp. 1004–1008 January 15.

13. —— A list of some reptiles from southeastern Arizona, with a description of a new species of *Cnemidophorus*. *Proceedings of the California Academy of Sciences*, ser. 2, vol. 6, pp. 338–349, pls. 49–50, August 18.

14. —— Description of a new lizard *(Eumeces gilberti)* from the Sierra Nevada of California. *Proceedings of the California Academy of Sciences*, ser. 2, vol. 6, pp. 350–352, August 28.

15. 1897. Reptiles from Sonora, Sinaloa, and Jalisco, Mexico, with a description of a new species of Sceloporus. *Proceedings of the Academy of Natural Sciences, Philadelphia*, pp. 460–464, November.

16. —— Some experiments with the saliva of the gila monster *(Heloderma suspectum)*. *Proceedings of the American Philosophical Society*, pp. 199–220, November.

17. —— The reptiles of the Pacific Coast and Great Basin. *Occasional Papers of the California Academy of Sciences*, no. 5, 236 pp., June (issued September 4).

18. 1898. The *Gerrhonotus* of the San Lucan fauna, Lower California, with diagnoses of other West American species. *Proceedings of the Academy of Natural Sciences, Philadelphia*, pp. 63–66.

19. —— Birds observed in central California in the summer of 1893. *Proceedings of the Academy of Natural Sciences, Philadelphia*, pp. 206–218, April.

20. —— Herpetological notes. *Proceedings of the American Philosophical Society*, vol. 37, no. 157, pp. 139–141.

21. 1899. Notes on some birds of Santa Clara County, California. *Proceedings of the American Philosophical Society*, vol. 38, no. 160, pp. 157–180.

22. 1900. ———— and Wright, Otis B. On the physiological action of the poisonous secretion of the gila monster *(Heloderma suspectum)*. *American Journal of Physiology*, vol. 4, no. 5, pp. 209–238, September.

23. 1905. The reptiles and amphibians of the islands of the Pacific Coast of North America from the Farallons to Cape San Lucas and the Revilla Gigedos. *Proceedings of the California Academy of Sciences*, ser. 3, vol. 4, no. 1, pp. 1–41, 8 pls., June 13 (issued: June 15).

24. —— The species of the reptilian genus *Anniella*, with especial reference to *Anniella texana* and to variation in *Anniella nigra*. *Proceedings of the California Academy of Sciences*, ser. 3, vol. 4, no. 2, pp. 41–49, November 29 (issued: December 2).

25. —— On the occurrence of the leather-back turtle, *Dermochelys*, on the coast of California. *Proceedings of the California Academy of Sciences*, ser. 3, vol. 4, no. 3, pp. 51–61, pls. 9–11, November 29 (issued: December 2).

26. 1906. Description of a new species of the genus *Plethodon (Plethodon vandykei)* from Mount Rainier, Washington. *Proceedings of the California Academy of Sciences*, ser. 3, vol. 4, no. 4, pp. 61–63, March 12 (issued: March 14).

27. —— On the occurrence of the spotted night snake, *Hypsiglena ochrorhynchus*, in central California; and on the shape of the pupil in the reptilian genus *Arizona*. *Proceedings of the California Academy of Sciences*, ser. 3, vol. 4, no. 5, pp. 65–67, March 12 (issued: March 14).

28. 1907. Preliminary descriptions of four new racers of gigantic land tortoises from the Galapagos Islands. *Proceedings of the California Academy of Sciences*, ser. 4, vol. 1, pp. 1–6, December 19 (issued: December 20).

29. 1908. ——— ——— and Thompson, Joseph C. Description of a new species of sea snake from the Philippine Islands, with a note on the palatine teeth in the proteroglypha. *Proceedings of the California Academy of Sciences*, ser. 4, vol. 3, pp. 41–48, December 31.

30. 1909. New and previously unrecorded species of reptiles and amphibians from the island of Formosa. *Proceedings of the California Academy of Sciences*, ser. 4, vol. 3, pp. 49–56, December 20.

31. 1912. Notes on a collection of reptiles from southern California and Arizona. *Proceedings of the California Academy of Sciences*, ser. 4, vol. 3, pp. 147–154, January 15 (issued: January 17).

32. 1912. Notes on some reptiles and amphibians from Oregon, Idaho, and Utah. *Proceedings of the California Academy of Sciences*, ser. 4, vol. 3, pp. 155–160, January 15 (issued: January 17).

33. —— The snakes of the Galapagos Islands. *Proceedings of the California Academy of Sciences*, ser. 4, vol. 1, no. 4, pp. 323–374, pls. 22–30, January 15 (issued: January 17).

34. —— The geckos of the Galapagos Archipelago. *Proceedings of the California Academy of Sciences*, ser. 4, vol. 1, no. 6, pp. 405–430, April 12 (issued: April 16).

35. —— Advance diagnoses of new reptiles and amphibians from the Loo Choo Islands and Formosa. Privately printed; San Francisco. 8 pp., July 29.

36. —— Concerning certain species of reptiles and amphibians from China, Japan, the Loo Choo Islands, and Formosa. *Proceedings of the California Academy of Sciences*, ser. 4, vol. 3, pp. 187–258, December 13 (issued: December 16).

37. —— Notes on *Ascaphus*, the discoglossid toad of North America. *Proceedings of the California Academy of Sciences*, ser. 4, vol. 3, pp. 259–264, 1 fig., December 20 (issued: December 21).

38. 1913 ——— ——— and Slevin, Joseph R. The Galapagoan lizards of the genus *Tropidurus;* with notes on the iguanas of the genera *Conolophus* and *Amblyrhynchus*. *Proceedings of the California Academy of Sciences*, ser. 4, vol. 2, part 1, no. 9, pp. 133–202, pls. 8–11, September 17 (issued: September 19).

39. —— ——— ——— and Slevin, Joseph R. A list of the amphibians and reptiles of Arizona, with notes on the species in the collection of the Academy. *Proceedings of the California Academy of Sciences*, ser. 4, vol. 3, pp. 391–454, pls. 17–28, November 3 (issued: November 5).

40. —— Review of Loeb's "The venom of *Heloderma*." *Science*, new ser., vol. 38, no. 991, pp. 931–932, December 26.

41. 1914. The gigantic land tortoises of the Galapagos Archipelago. *Proceedings of the California Academy of Sciences*, ser. 4, vol. 2, part 1, pp. 203–374, pls. 12–124, September 30.

42. 1914. ——— ——— and Slevin, Joseph R. Reptiles and amphibians of the islands of the West Coast of North America. *Proceedings of the California Academy of Sciences*, ser. 4, vol. 4, no. 5, pp. 129–152, December 30.

43. 1915. ———— ———— and Slevin, Joseph R. A list of the amphibians and reptiles of Utah, with notes on the species in the collection of the Academy. *Proceedings of the California Academy of Sciences*, ser. 4, vol. 5, no. 4, pp. 99–110, pls. 12–14, June 15.

44. 1916. On the probable origin of the type specimen of Cope's *Xantusia picta*. *Copeia*, no. 27, pp. 14–15, February 24.

45. —— Four species of salamanders new to the State of California, with a description of *Plethodon elongatus*, a new species, and notes on other salamanders. *Proceedings of the California Academy of Sciences*, ser. 4, vol. 6, no. 7, pp. 215–221, May 12.

46. 1917. Report of the Department of Herpetology for 1916. *Proceedings of the California Academy of Sciences*, ser. 4, vol. 6, no. 9, pp. 253–254, June 23.

47. —— Notes on the herpetology of Guam, Marianas Islands. *Proceedings of the California Academy of Sciences*, ser. 4, vol. 7, no. 3, pp. 37–39, July 23.

48. —— Concerning the origin of the soft-shelled turtle, *Aspidonectes californiana* Rivers. *Proceedings of the California Academy of Sciences*, ser. 4, vol. 7, no. 2, pp. 33–35, July 23.

49. 1918. Report of the Department of Herpetology for 1917. *Proceedings of the California Academy of Sciences*, ser. 4, vol. 7, no. 13, pp. 351–352, June 15.

50. —— ———— ———— and Slevin, Joseph R. The garter snakes of western North America. *Proceedings of the California Academy of Sciences*, ser. 4, vol. 8, no. 6, pp. 181–270, pls. 7–17, October 18.

51. 1919. Nesting of the western willet in California. *Condor*, vol. 21, no. 1, pp. 39–40, Jan.–Feb.

52. 1919. Report of the Department of Herpetology for 1918. *Proceedings of the California Academy of Sciences*, ser. 4, vol. 8, no. 9, pp. 335–337, June 16.

53. —— ———— ———— and Slevin, Joseph R. The gopher snakes of western North America. *Proceedings of the California Academy of Sciences*, ser. 4, vol. 9, no. 6, pp. 197–220, pls. 11–13, August 21.

54. —— A note on *Xantusia riversiana*. *Copeia*, no. 75, pp. 91–92, November 20.

55. 1920. Mr. Boulenger on the genus *Babina*. *Copeia*, no. 79, pp. 14–16, February 27.

56. —— Report of the Department of Herpetology for 1919. *Proceedings of the California Academy of Sciences*, ser. 4, vol. 9, no. 15, pp. 384–385, August 4.

57. —— A further study of variation in the gopher snakes of western North America. *Proceedings of the California Academy of Sciences*, ser. 4, vol. 10, no. 1, pp. 1–27, pls. 1–2, August 6.

58. —— Description of a new species of rattlesnake *(Crotalus lucasensis)* from Lower California. *Proceedings of the California Academy of Sciences*, ser. 4, vol. 10, no. 2, pp. 29–30, pl. 3, August 6.

59. —— Description of a new subspecies of boa *(Charina bottae utahensis)* from Utah. *Proceedings of the California Academy of Sciences*, ser. 4, vol. 10, no. 3, pp. 31–32, August 6.

60. —— Description of a new lizard *(Dipsosaurus dorsalis lucasensis)* from Lower California. *Proceedings of the California Academy of Sciences*, ser. 4, vol. 10, no. 4, pp. 33–34, August 6.

61. 1921. Report of the Department of Herpetology for 1920. *Proceedings of the California Academy of Sciences*, ser. 4, vol. 10, no. 12, pp. 141–142, July 2.

62. —— ———— and Slevin, Joseph R. A list of the amphibians and reptiles of Nevada, with notes on the species in the collection of the Academy. *Proceedings of the California Academy of Sciences*, ser. 4, vol. 11, no. 2, pp. 27–38, July 8.

63. 1921. ———— and Slevin, Joseph R. A list of the amphibians and reptiles of Idaho, with notes on the species in the collection of the Academy. *Proceedings of the California Academy of Sciences*, ser. 4, vol. 11, no. 3, pp. 39–47, July 8.

64. —— ———— and Slevin, Joseph R. A list of the reptiles and amphibians of the peninsula of Lower California, with notes on the species in the collection of the Academy. *Proceedings of the California Academy of Sciences*, ser. 4, vol. 11, no. 4, pp. 49–72, July 8.

65. —— ———— and Slevin, Joseph R. Preliminary diagnoses of the new species of reptiles from the islands in the Gulf of California, Mexico. *Proceedings of the California Academy of Sciences*, ser. 4, vol. 11, no. 6, pp. 95–98, July 30.

66. —— ———— and Slevin, Joseph R. Preliminary diagnoses of more new species of reptiles from the islands in the Gulf of California, Mexico. *Proceedings of the California Academy of Sciences*, ser. 4, vol. 11, no. 17, pp. 395–398, December 17.

67. 1922. A fourth specimen of a rare snake from Texas. *Copeia*, no. 104, p. 24, March 20.

68. —— An unusual type of abnormal coloration in lizards. *Copeia*, no. 106, pp. 38–39, May 30.

69. —— Report of the Department of Herpetology for 1921. *Proceedings of the California Academy of Sciences*, ser. 4, vol. 11, no. 21, pp. 631–632, August 21.

70. —— The reptiles of western North America. *Occasional Papers of the California Academy of Sciences*, 2 vols., 1028 pp., 128 pls., November 23.

71. 1923. ———— and Slevin, Joseph R. Preliminary diagnoses of four new snakes from Lower California, Mexico. *Proceedings of the California Academy of Sciences*, ser. 4, vol. 13, no. 1, pp. 1–2, July 25.

72. —— A new subspecies of watersnake *(Natrix vibakari ruthveni)* from eastern Asia. *Proceedings of the California Academy of Sciences*, ser. 4, vol. 13, no. 2, pp. 3–4, July 26.

73. —— Report of the Department of Herpetology for 1922. *Proceedings of the California Academy of Sciences*, ser. 4, vol. 11, no. 23, pp. 679–680, August 22.

74. 1924. Notes on the herpetology of New Mexico, with a list of species known from that state. *Proceedings of the California Academy of Sciences*, ser. 4, vol. 13, no. 12, pp. 189–230, March 18.

75. —— The birds of the Todos Santos Islands. *Condor*, vol. 26, no. 2, pp. 67–71, March–April.

76. —— A fifth record of the Pacific leather-back turtle on the coast of California. *Copeia*, no. 130, p. 53, May 31.

77. —— Contributions to Oriental herpetology, I. Sakhalin. *Proceedings of the California Academy of Sciences*, ser. 4, vol. 13, no. 15, pp. 243–246, November 6.

78. —— On *Laticauda schistorhynchus* and *Laticauda semifasciata*. *Proceedings of the California Academy of Sciences*, ser. 4, vol. 13, no. 16, pp. 247–248, November 6.

79. —— Report of the Department of Herpetology for 1923. *Proceedings of the California Academy of Sciences*, ser. 4, vol. 12, no. 33, p. 1263.

BIBLIOGRAPHY OF JOSEPH RICHARD SLEVIN

Curator of Herpetology, California Academy of Sciences, 1925–

1. 1913. Van Denburgh, John, and ————. The Galapagos lizards of the genus *Tropidurus;* with notes on the iguanas of the genera *Conolophus* and *Amblyrhynchus*. *Proceedings of the California Academy of Sciences*, ser. 4, vol. 2, part 1, no. 9, pp. 133–202, pls. 8–11, September 17 (issued: September 19).

2. —— Van Denburgh, John, and ————. A list of the amphibians and reptiles of Arizona, with notes on the species in the collection of the Academy. *Proceedings of the California Academy of Sciences*, ser. 4, vol. 3, pp. 391–454, pls. 17–28, November 3 (issued: November 5).

3. 1914. Van Denburgh, John, and ————. Reptiles and amphibians of the islands of the West Coast of North America. *Proceedings of the California Academy of Sciences*, ser. 4, vol. 4, no. 5, pp. 129–152, December 30.

4. 1915. Van Denburgh, John, and ————. A list of the amphibians and reptiles of Utah, with notes on the species in the collection of the Academy. *Proceedings of the California Academy of Sciences*, ser. 4, vol. 5, no. 4, pp. 99–110, pls. 12–14, June 15.

5. 1918. Van Denburgh, John, and ————. The garter snakes of western North America. *Proceedings of the California Academy of Sciences*, ser. 4, vol. 8, no. 6, pp. 181–270, pls. 7–17, October 18.

6. 1919. Van Denburgh, John, and ————. The gopher snakes of western North America. *Proceedings of the California Academy of Sciences*, ser. 4, vol. 9, no. 6, pp. 197–220, pls. 11–13, August 21.

7. 1921. Van Denburgh, John, and ————. A list of the amphibians and reptiles of Nevada, with notes on the species in the collection of the Academy. *Proceedings of the California Academy of Sciences*, ser. 4, vol. 11, no. 2, pp. 27–38, July 8.

8. 1921. Van Denburgh, John, and ————. List of the amphibians and reptiles of Idaho, with notes on the collection of the Academy. *Proceedings of the California Academy of Sciences*, ser. 4, vol. 11, no. 3, pp. 39–47, July 8.

9. —— Van Denburgh, John, and ————. A list of the reptiles and amphibians of the peninsula of Lower California, with notes on the species in the collection of the Academy. *Proceedings of the California Academy of Sciences*, ser. 4, vol. 11, no. 4, pp. 49–72, July 8.

10. —— VAN DENBURGH, JOHN, and ————. Preliminary diagnoses of new species of reptiles from the islands in the Gulf of California, Mexico. *Proceedings of the California Academy of Sciences*, ser. 4, vol. 11, no. 6, pp. 95–98, July 30.

11. —— VAN DENBURGH, JOHN, and ————. Preliminary diagnoses of more new species of reptiles from islands in the Gulf of California, Mexico. *Proceedings of the California Academy of Sciences*, ser. 4, vol. 11, no. 17, pp. 395–398, December 17.

12. 1923. Expedition of the California Academy of Sciences to the Gulf of California in 1921. General account. *Proceedings of the California Academy of Sciences*, ser. 4, vol. 12, no. 6, pp. 55–72, 1 map, June 2.

13. —— VAN DENBURGH, JOHN, and ————. Preliminary diagnoses of four new snakes from Lower California, Mexico. *Proceedings of the California Academy of Sciences*, ser. 4, vol. 13, no. 1, pp. 1–2, July 25.

14. 1925. Annual report, Department of Herpetology for the year 1924. *Proceedings of the California Academy of Sciences*, ser. 4, vol. 13, no. 28, p. 473, May 29.

15. —— Contributions to Oriental herpetology. II. Korea or Chosen. *Proceedings of the California Academy of Sciences*, ser. 4, vol. 14, no. 5, pp. 89–100, July 23.

16. —— Contributions to Oriental herpetology. III. Russian Asia and Manchuria. *Proceedings of the California Academy of Sciences*, ser. 4, vol. 14, no. 6, pp. 101–103, July 23.

17. 1926. Expedition to the Revillagigedo Islands, Mexico, in 1925. III. Notes on a collection of reptiles and amphibians from the Tres Marias and Revillagigedo Islands, and west coast of Mexico, with description of a new species of *Tantilla*. *Proceedings of the California Academy of Sciences*, ser. 4, vol. 15, no. 3, pp. 195–207, pl. 22, April 26.

18. —— Annual report, Department of Herpetology for the year 1925. *Proceedings of the California Academy of Sciences*, ser. 4, vol. 14, no. 20, p. 542, April 28.

19. 1927. An additional record of the leather-back turtle on the coast of California. *Copeia*, no. 159, pp. 172–173, January 11.

20. —— Annual report, Department of Herpetology for the year 1926. *Proceedings of the California Academy of Sciences*, ser. 4, vol. 15, no. 18, pp. 534–535, March 31.

21. —— The making of a scientific collection of reptiles and amphibians. *Proceedings of the California Academy of Sciences*, ser. 4, vol. 16, no. 9, pp. 231–259, pls. 15–16, April 22.

22. 1928. Description of a new species of lizard from Malpelo Island. *Proceedings of the California Academy of Sciences*, ser. 4, vol. 16, no. 21, pp. 681–684, pls. 25–26, February 28.

23. —— The amphibians of western North America. *Occasional Papers, California Academy of Sciences*, vol. 16, 152 pp., 23 pls.

24. 1929. A contribution to our knowledge of the nesting habits of the golden eagle. *Proceedings of the California Academy of Sciences*, ser. 4, vol. 18, no. 3, pp. 45–71, pls. 4–7, January 29.

25. 1930. Contributions to Oriental herpetology. IV. Hokushu or Yezo. *Proceedings of the California Academy of Sciences*, ser. 4, vol. 19, no. 10, pp. 105–108, July 15.

26. —— Further notes on the genus *Ensatina*. *Copeia*, no. 3, pp. 77–78, September 30.

27. —— A note on the discovery of the genus *Typhlops* in the Hawaiian Islands. *Copeia*, no. 4, p. 158.

28. 1931. A tank designed to overcome the difficulties met in making a collection of alcoholics. *The Museum News*, vol. 8, no. 17, p. 12, March 1.

29. —— Range extension of certain western species of reptiles and amphibians. *Copeia*, no. 3, pp. 140–141, October.

30. 1932. The yellow-bellied sea snake. *The Aquarium Journal*, vol. 5, no. 8, p. 46, October 6.

31. 1934. A handbook of reptiles and amphibians of the Pacific States including certain Eastern species. Specially adapted to the use of the nature student. Special Publication, California Academy of Sciences, 73 pp.

32. —— The Templeton Crocker expedition to western Polynesian and Melanesian islands, 1933. No. 15. Notes on the reptiles and amphibians, with the description of a new species of sea snake. *Proceedings of the California Academy of Sciences*, ser. 4, vol. 21, no. 15, pp. 183–188, October 16.

33. 1935. An account of the reptiles inhabiting the Galapagos Islands. *Bulletin of the New York Zoological Society*, vol. 38, no. 1, pp. 2–24, January–February.

34. —— Outposts of Baja California; desert islands where a vanishing fauna is making a valiant struggle to survive. *Natural History*, vol. 37, no. 6, pp. 65–73, June.

35. —— An equatorial wonderland. The Galapagos—a country of great volcanoes, giant tortoises, and flightless birds. *Natural History*, vol. 36, pp. 374–388, December.

36. 1936. Tame "waterfowl" of the Galapagos Islands: An archipelago where the unique avifauna lives unmolested by man. *The Illustrated London News*, vol. 188, no. 5065, pp. 873–875, May 16.

37. —— A new Central American snake. *Proceedings of the California Academy of Sciences*, ser. 4, vol. 23, no. 4, pp. 79–81, August 12.

38. 1937. John Marshall Gamble. *Paradise of the Pacific*, vol. 49, no. 7, July.

39. 1937. Contributions to Oriental herpetology, V. Honshu or Hondo, the neighboring islands of Sado and Awaji, and the seven islands of Idzu. *Proceedings of the California Academy of Sciences*, ser. 4, vol. 23, no. 11, pp. 175–190, December 30.

40. 1939. Notes on a collection of reptiles and amphibians from Guatemala. I. Snakes. *Proceedings of the California Academy of Sciences*, ser. 4, vol. 23, no. 26, pp. 393–414, pls. 37–38, December, 29.

41. 1940. "Lost grave of Cowan on Galapagos." *Paradise of the Pacific*, vol. 52, no. 6, pp. 25–26, June.

42. —— Wildlife disappearing from Cedros, the largest of Baja California's coastal islands is meeting the same fate as its neighbor Guadalupe. *Bulletin of the New York Zoological Society*, vol. 43, no. 6, pp. 192–196, November–December.

43. 1941. Swift desert beauties. Some interesting lizards of the arid Southwest. *Nature Magazine*, vol. 34, no. 2, pp. 73–76, February.

44. 1942. Notes on a collection of reptiles and amphibians from Guatemala. II. Lizards. *Proceedings of the California Academy of Sciences*, ser. 4, vol. 23, no. 31, pp. 453–462, June 25.

45. —— Notes on a collection of reptiles from Boquete, Panama, with the description of a new species of *Hydromorphus*. *Proceedings of the California Academy of Sciences*, ser. 4, vol. 23, no. 32, pp. 463–480, pls. 39–42, June 25.

46. —— In the Australian bush. *Nature Magazine*, vol. 35, no. 9, pp. 473–476, November.

47. 1946. A visit to the crater of the Volcan Chiriquí. *Herpetologica*, vol. 3, part 2, pp. 62–63, February 23.

48. 1947. An abnormal condition in the transparent spectacle of a coast gopher snake. *Herpetologica*, vol. 4, part 1, p. 30, September 17.

49. 1948. A reptile hunter's Australia. *Pacific Discovery*, vol. 1, no. 5, pp. 20–28, September–October.

50. 1949. Range extension of *Xantusia vigilis*. *Herpetologica*, vol. 5, part 6, p. 148, December 15.

51. 1950. A remarkable concentration of desert snakes. *Herpetologica*, vol. 6, part 1, pp. 12–13, March 8.

52. —— Post office in a barrel. *Pacific Discovery*, vol. 3, no. 2, pp. 28–29, March–April.

53. 1951. A high birthrate for *Natrix sipedon sipedon*. *Herpetologica*, vol. 7, part 3, p. 132, September 13.

54. —— The San Felipe road—a snake hunter's disappointment. *Herpetologica*, vol. 7, part 4, pp. 191–192, 4 photos, December 31.

55. 1954. Australian "Double-header." *Pacific Discovery*, vol. 7, no. 2, p. 13, 2 figs., March–April.

56. 1955. Notes on Australian amphibians. *Proceedings of the California Academy of Sciences*, ser. 4, vol. 98, no. 8, pp. 355–392, June 30.

57. 1955. Charting the "Enchanted Isles." In: Essays in the Natural Sciences in honor of Captain Allan Hancock. University of Southern California Press, pp. 99–110, 4 maps.

BIBLIOGRAPHY OF JOSEPH CHEESMAN THOMPSON

Assistant Curator of Herpetology, California Academy of Sciences, 1908–1912

(Note: This bibliography includes only Thompson's herpetological papers.)

1. 1908. Van Denburgh, John, and ——— ———. A new sea snake. *Proceedings of the California Academy of Sciences*, ser. 3, vol. 4, pp. 41–47, 1 pl.

2. 1912. Description of a new genus and species of salamander from Japan. *Proceedings of the California Academy of Sciences*, ser. 3, vol. 9, pp. 183–186, May 3.

3. —— Prodrome of a description of a new genus of Ranidae from the Loo Choo Islands. *Herpetological Notices* [privately printed], San Francisco, no. 1, pp. 1–3, June 15.

4. —— Prodrome of descriptions of new species of Reptilia and Batrachia from the Far East. *Herpetological Notices* [privately printed], San Francisco, no. 2, pp. 1–4, June 28.

5. —— On reptiles new to the island arcs of Asia. *Herpetological Notices* [privately printed], San Francisco, no. 3, pp. 1–5, July 31.

6. 1913. *Oxyrhopus trigeminus* Duméril and Bibron, the type of *Erythroxyrhopus* gen. nov. *Proceedings of the Academy of Natural Sciences, Philadelphia*, vol. 65, pp. 78–80, February.

7. —— Notes on serpents in the Family Colubridae. *Proceedings of the Academy of Natural Sciences, Philadelphia*, vol. 65, pp. 213–218, April.

8. —— Contributions to the anatomy of the Ophidia. *Procedings of the Zoological Society, London*, pp. 414–425.

9. —— Contributions to the synonymy of serpents in the Family Elapidae. *Proceedings of the Academy of Natural Sciences, Philadelphia*, vol. 65, pp. 508–514, September.

10. —— The variations exhibited by mainland and island specimens of the hibakari snake, *Natrix vibakari* (Boie). *Proceedings of the United States National Museum*, vol. 46, no. 2020, pp. 157–160, September 30.

11. 1914. Contribution to the anatomy of the Ilysiidae. *Proceedings of the Academy of Natural Sciences, Philadelphia*, vol. 66, pp. 285–293, April.

12. —— The variations exhibited by *Thamnophis ordinoides* (Baird and Girard), a garter snake inhabiting the Sausalito Peninsula, California. *Proceedings of the United States National Museum*, vol. 47, no. 2051, pp. 351–360, May 16.

13. —— Further contributions to the anatomy of the Ophidia. *Proceedings of the Zoological Society, London*, pp. 379–402.

14. 1916. The variations exhibited by *Ancistrodon halys* (Pallas), a pit-viper inhabiting the Far East. *Transaction of the San Diego Society of Natural History*, vol. 10, no. 2, pp. 59–76.

15. 1917. The variation exhibited by *Thamnophis ordinoides* (Baird and Girard), a garter snake inhabiting the San Francisco Peninsula. *Proceedings of the United States National Museum*, vol. 52, no. 2179, pp. 345–366, March 7.

PROCEEDINGS
OF THE
CALIFORNIA ACADEMY OF SCIENCES
Fourth Series
Vol. XXVIII, No. 15, pp. 561–613, 19 figs. November 19, 1956

REVISION OF THE NEARCTIC SPECIES OF PHOTINUS *(LAMPYRIDAE: COLEOPTERA)*

BY
JOHN WAGENER GREEN
California Academy of Sciences

The present revision is the first attempt to segregate and define the Nearctic species of *Photinus* since the publication of LeConte's *Synopsis of the Lampyridae* in 1881. Subsequently six species were described as new by Fall and Olivier, and other new ones have accumulated in collections, more than doubling the total number known to LeConte. It has been found that several of the published names must be reduced to synonymy. The classification of the Nearctic species herein proposed provides a phylogenetic arrangement that may readily be amplified for the inclusion of Neotropical forms.

Except in the male genitalia, structural diversity of a definite nature is completely lacking for many of the species. Differences in body form, sculpture, and color pattern are noted, but all are more or less subject to variation. In color the Nearctic species conform closely to a general plan. This will be described now and need not be repeated in the species descriptions, where only pertinent modifications will be noted. The head, antennae, and elytra are dark rufous or brown, varying to nearly black; with the sutural, lateral, and apical borders of the elytra narrowly pale flavate or fulvous. The pronotum is pale flavate or fulvous with a central dark spot. The ventral surface, except anteriorly, and the legs, except at base, are rufous or brown, varying to nearly black, with the luminous areas of the abdomen pale testaceous. Color characters of taxonomic value are found in the formation of the pronotal dark spot, the color of the scutellum and adjoining mesonotal areas, the width of the lateral pale border of the elytra, and the color of the pygidium and of ventral segment 5. In one of the species the elytra are entirely black.

The first abdominal segment in adult Lampyridae is dorsal only, the first visible ventral segment belonging to the second segment of the abdomen. In numbering the ventral segments, therefore, the numbers will always be one greater than the actual count of the visible ventral segments. The sternites occupy only the median half, more or less, of each ventral segment except the terminal. The lateral part, on each side, represents the pleurite, which at its outer margin is narrowly inflexed and becomes dorsal. This small dorsal part bears the spiracle in *Photinus,* and in most of the other lampyrid genera. In the Pleotomi and Lamprocerae, however, the spiracle is located in the ventral portion of the pleurite near its outer margin. The suture between pleurite and sternite is plainly evident in the larval stage, but in the adult this suture is obliterated and indicated only by a vague longitudinal depression. In view of the above, it would be incorrect to refer to the ventral segments of the abdomen as sternites.

The Nearctic species of *Photinus* separate into two primary divisions, each characterized by a distinctive type of male genitalia. The first division forms a homogeneous taxonomic unit that in all probability should be accorded generic rank. The genitalia are greatly diversified in these species, which are otherwise so similar in appearance that they have heretofore been mostly overlooked. In the species of Division II the median lobe of the aedeagus is provided with two sclerotized ventro-basal processes projecting outwardly, one on each side, more or less over the lateral lobes. These processes are lacking in the species of Division I. In Division II the genitalia serve to define a number of species groups, but are for the most part of little value for specific determinations within each group because of a close similarity and a very evident degree of structural plasticity.

In certain lampyrid genera, e.g. *Phausis* and *Cratomorphus,* the distal abdominal tergites are produced at the sides over the dorsal part of their pleurites and are widely visible from a ventral viewpoint. In such a case the abdomen was said to be lobed or foliate by earlier authors. Foliation is completely lacking in the *Photinus* species of Division I. Incipient foliation occurs in all of the species of the *P. punctulatus, P. consanguineus,* and *P. ardens* groups of Division II, where tergites 6 and 7 are narrowly visible at the sides from below. The *pyralis* group of Division II occupies an intermediate position, with the first two species as in Division I, and the last species approaching the structure found in the groups following.

The epipleurae of *Photinus* are quite wide at the base of the elytra, embracing the sides of the body. The inner epipleural margin rapidly approaches the external margin to form a triangular basal part, extending posteriorly to about the basal seventh of the elytral length. The inner epipleural margin thence continues as a more or less distinct raised line on the underside of the elytra, obsolescing without reaching the apex. Slight variations of this pattern occur according to species. A rather feebly distinct but recognizable type characterizes all of the species of Division I: the wide basal part is less abruptly narrowed posteriorly and merges gradually into the narrow distal part, the latter is wider and with a better defined inner margin that is more nearly in the same plane as the exterior margin, so that the epipleurae may be described as subhorizontal.

Collectors are especially urged to look for the females of those species of *Photinus* in which that sex is flightless. Very few of these are at present in collections, while two of the Nearctic species believed to have brachypterous females are still known only by the male. The author has frequently taken the flightless females of *Photinus scintillans* in the early evening, just before dark, by looking in the grass and low herbage over which the males are flying. The presence of a female is indicated by a feeble flash emitted as the male is approaching, after having alighted nearby. The flightless females, such as have been examined, are not apterous by have rudimentary wings under their very short elytra.

Mr. H. S. Barber found the flashing habits of *Photuris* to be distinctive for many of the species and useful in their identification. It is probable that the same is true of *Photinus*. Barber and F. A. McDermott have recorded flash data with the specimens they collected, but very little other information on the subject is available. In some of the species observed, such as *P. scintillans* and *P. marginellus*, and probably also for many others, the males in flight produce single short flashes. Both single and double flashes have been noted for *P. consanguineus* in apparently identical specimens collected at the same time and place. Males of the *P. ardens* group are recognizable in flight by a multiple flash of from four to seven short illuminations in quick succession. The flash of *P. pyralis* is characteristic. It always occurs as the insect is slowly rising in a vertical direction after an inclined descending flight. The flash does not end abruptly but is followed by a short and dim afterglow.

The generic synonymy, as it stands in the literature, has been omitted from this discussion. It is in need of verification by a study of type species that are not now available. Probably some at least of the published synonyms should be restored as valid genera. This will be particularly desirable when the very large number of still undescribed species shall have been made known. The presence of luminous areas and the dissimilarity of the sexes are not necessarily characters of generic importance, as they have heretofore been considered.

The material on which this revision was based came from many sources in addition to the extensive collections of the California Academy of Sciences. The author wishes to express his sincere thanks and appreciation to the following for the loan or gift of specimens over a period of years, or for otherwise cooperating in this study: Agricultural and Mechanical College of Texas, L. S. Dillon and H. J. Reinhard; American Museum of Natural History, Mont A. Cazier; University of Arkansas, L. H. Rolston; University of California, Paul D. Hurd; University of California at Los Angeles, J. N. Belkin; Carnegie Museum, George Wallace; Chicago Natural History Museum, Henry Dybas; Cornell University, Henry Dietrich; University of Delaware, Chas. Triplehorn; Emory University, the late P. W. Fattig; Entomological Laboratory at Augusta, Maine, A. E. Brower; University of Florida, Lewis Berner; Florida State Plant Board, H. V. Weems, Jr.; Illinois Natural History Survey, M. W. Sanderson; University of Kansas, R. H. Beamer; Kansas State College, George A. Dean and Fred A. Lawson; University of Michigan, T. H. Hubbell; University of Missouri, W. R. Enns; North Carolina Department of Agriculture, D. L. Wray; University of Ohio, W. C. Stehr; Ohio State University, J. N. Knull; Ohio State Museum, E. S. Thomas; Oregon State College; South Dakota State College, H. C. Severin; U. S. National Museum, O. L. Cartwright and Ross H. Arnett, Jr.; Owen Bryant; Carl Cook; P. J. Darlington for the privilege of studying the type material of LeConte and Fall at the Museum of Comparative Zoology; R. R. Dreisbach; K. M. Fender; C. A. Frost; Borys Malkin; M. Y. Marshall; E. J. F. Marx; A. T. McClay; F. A. McDermott; P. J. Spangler; and George Steyskal.

Genus **Photinus** Castlenau

Photinus Castlenau, 1833, Soc. Ent. France, Ann. 2:141
Photinus Lacordaire, 1857, Gen. Col., 4:321.

In addition to its general lampyrid structure, the genus *Photinus,* as represented in the Nearctic fauna, is characterized as follows. Body texture soft; form elongate oval, lateral margins subparallel. Head strongly deflexed, when retracted it is completely covered by pronotum; gula semimembranous, greatly abbreviated medially by a forward extension of occipital foramen; eyes large, hemispherical. Antennae simple, slender, compressed, 11-segmented, without minute terminal appendix, similar in the sexes, less than half as long as body, with coarse and somewhat bristling pubescence; second segment short, following segments elongate, subequal to each other in length, gradually more slender distally. Clypeus feebly sclerotized, with membranous basal articulation; labrum elongate triangular, membranous; mandibles acute, arcuate, regularly narrowed from base to apex, excepting the internal basal enlargement. Maxillary palpi short and stout, broader distally, second segment not elongated; terminal segment of labial palpi triangular or securiform, its apex truncate or rounded.

Pronotum semielliptic, anterior angles obliterated, posterior angles subrectangular, sides and front explanate. Elytra with dual pubescence, minute secondary pubescence usually broadly lacking at base; epipleurae completely defined externally by the acute elytral margin, wide at base, rapidly narrowing to about basal seventh, thence narrowly subparallel, obliterated before reaching elytral apex. Prosternum truncate in front; anterior margin of hypomera not attaining lateral margin of thorax; anterior thoracic spiracles prominent, transverse, subtubulate, overlapping the mesepisterna. Abdominal spiracles dorsal.

Abdomen of male with eight visible ventral segments, the two terminal covered by pygidium; light organs, when present, occupying all of ventral segments 6 and 7, these segments each longer than any preceding segment and each with a pair of stigmatiform pores. Female with seven visible ventral segments; light organs, when present, occupying median third or more of the width of segment 6. Legs short and stout, compressed; tibial spurs small, slender and acute, concealed by the apical setae; terminal segment of tarsi extending for less than half its length beyond lobes of deeply emarginate fourth segment; claws simple.

KEY TO MALES OF NEARCTIC *Photinus*

1. Median lobe of aedeagus without ventro-basal processes. Epipleurae subhorizontal, gradually narrowing from base. Ventral segments 6 and 7 transversely convex, segment 5 with pale apical border (except in *P. cookii)*. Females alate, similar to male .... Division I–2

— Median lobe of aedeagus with two sclerotized ventro-basal processes. Epipleurae more strongly inflexed, rapidly narrowing to about basal seventh....Division II–9

DIVISION I

2. Lateral lobes of aedeagus each with a dorsal branch embracing sides of median lobe 3

— Lateral lobes of aedeagus without dorsal branches 7

3. Median lobe of aedeagus extending notably beyond tips of lateral lobes........ 4

— Median lobe of aedeagus not extending beyond tips of lateral lobes........ 5

4. Pronotum with median dark spot, scutellum and mesonotal areas dark piceous. Aedeagus as in figure 1 .... (1) *P. texanus* Green, new species

— Pronotum without median dark spot, scutellum and mesonotal areas pale fulvous. Aedeagus as in figure 2 .... (2) *P. immaculatus* Green, new species

5. Species non-luminous, ventral segments 6 and 7 each subequal in length to segment 5, segments 2 to 5 entirely dark piceous....(3) *P. cookii*, Green, new species

— Species luminous, ventral segments 6 and 7 each distinctly longer than any preceding segment, segment 5 with pale apical border 6

6. Median lobe of aedeagus attenuate distally; lateral lobes arcuately ascending, elongate, their dorsal branches long and slender, nearly meeting above........ .... (4) *P. marginellus* LeConte

— Median lobe of aedeagus not attenuate distally; lateral lobes stout, not ascending, their dorsal branches short, tips distant above ....(5) *P. curtatus* Green, new species

7. Median lobe of aedeagus extending well beyond tips of lateral lobes .... (6) *P. floridanus* Fall

— Median lobe of aedeagus not extending beyond tips of lateral lobes.................. 8

8. Pygidium strongly longitudinally humped or roof-shaped. Lateral lobes of aedeagus strongly sclerotized, irregularly dentate within .... (7) *P. sabulosus* Green, new species

— Pygidium normal. Lateral lobes of aedeagus weakly sclerotized, not denticulate within, acuminate at tip........................... (8) *P. acuminatus* Green, new species

DIVISION II

9. Ventral segments 6 and 7 transversely convex, segment 5 with pale apical border ....*P. pyralis* group 12

— Ventral segments 6 and 7 nearly flat, segment 5 entirely dark piceous or black 10

10. Lateral lobes of aedeagus elongate, descending, their inner margins contiguous beneath tip of median lobe. Apex of pygidium rounded 11

— Lateral lobes of aedeagus short and stout, not descending, their inner margins separated throughout, or touching only beyond tip of median lobe. Apex of pygidium broadly truncate. Female alate, similar to male .... *P. consanguineus* group 22

11. Ventral segment 8 arcuately emarginate, without median apical process. Pronotum with median longitudinal line usually distinctly impressed. Female brachypterous, except in *P. umbratus* (unknown in *P. tenuicinctus* and *P. frosti)* ....*P. punctulatus* group 14

— Ventral segment 8 not or scarcely emarginate, its apical margin produced in a short median cusp. Pronotum without impressed median longitudinal line. Female alate, similar to male ....*P. ardens* group 26

P. pyralis Group

12. Dorsal surface of median lobe of aedeagus membranous in about distal third. Abdomen with basal segments piceous or partly so. Sexes similar 13

— Dorsal surface of median lobe of aedeagus not as above. Abdomen with basal segments entirely pale. Sexes dissimilar, female brachypterous.. (11) *P. scintillans* (Say)

13. Mandibles stout. Head nearly flat between eyes, surface smooth, with simple punctulation. Ventral segments 2 to 4 entirely dark piceous. Size larger, form more elongate .... (9) *P. pyralis* (Linné)

— Mandibles slender. Head concave between eyes, surface roughened with irregular granulose punctulation. Ventral segments 2 to 4 not entirely dark piceous, with poorly defined pale areas. Size smaller, form less elongate .... (10) *P. australis* Green, new species

P. punctulatus Group

14. Form normal, broader as in preceding species. Pronotum usually more narrowly rounded in front, lateral margins diverging posteriorly. Elytra each with lateral and sutural margins parallel from humerus to about apical fifth, round-

ing into apex. Antennae longer and more slender. Epipleurae distinct beyond wide basal part 15

— Form more elongate. Pronotum usually broadly rounded in front, lateral margins subparallel or feebly converging posteriorly. Elytra each tapering posteriorly, lateral and sutural margins feebly converging from humerus to near apex. Antennae shorter and stouter. Epipleurae extremely narrow except at base 19

15. Lateral pale border of elytra wider, plainly exceeding width of explanate margin medially. Epipleurae, scutellum, and mesonotal areas pale fulvous .... (12) *P. brimleyi* Green, new species

— Lateral pale border of elytra narrow, not exceeding width of explanate margin. Epipleurae usually fuscous basally 16

16. Pygidium pale, sharply contrasting with preceding dark piceous tergites. Disk of pronotum conspicuously and rather closely punctate .... (13) *P. punctulatus* LeConte

— Pygidium and preceding tergites concolorous, dark piceous 17

17. Lateral pale border of elytra very narrow, limited to outer edge of explanate margin .... (14) *P. tenuicinctus* Green, new species

— Lateral pale border of elytra occupying entire explanate margin 18

18. Disk of pronotum with coarser simple punctation. Scutellum dark piceous basally, mesonotal areas abruptly pale fulvous. (Female unknown, probably brachypterous) .... (15) *P. frosti* Green, new species

— Disk of pronotum minutely punctulate, punctures often subgranulate, especially at sides. Scutellum and mesonotal areas pale fulvous. Female alate, similar to male .... (16) *P. umbratus* LeConte

19. Pronotum immaculate or with anterior dark spot. Elytra more elongate, extending to tip of abdomen 20

— Pronotum with central dark spot. Elytra less elongate, usually not reaching abdominal apex 21

20. Elytral margins narrowly fulvous. Pronotum rufous with anterior third dark, the dark color rarely extending posteriorly .... (17) *P. collustrans* LeConte

— Elytra entirely black. Pronotum entirely rufous, or rarely somewhat dusky anteriorly .... (18) *P. stellaris* Fall

21. Pronotum distinctly granulate-punctate .... (19) *P. granulatus* Fall

— Pronotal punctation not granulate .... (20) *P. dimissus* LeConte

P. consanguineus Group

22. Aedeagus as in figure 16. Habitat southern Arizona .... (21) *P. knulli* Green, new species

— Aedeagus similar to Figure 17. Habitat eastern and mid-western states 23

23. Species non-luminous; ventral segments 6 and 7 each subequal in length to segment 5; abdomen entirely black, or irregularly paler apically. Eyes small .... (22) *P. indictus* (LeConte)

— Species luminous; ventral segments 6 and 7 entirely pale, each longer than segment 5. Eyes large 24

24. Pygidium pale, sharply contrasting with preceding dark piceous tergites. Form narrowly elongate. Epipleurae obsolete except at base .... (23) *P. lineellus* LeConte

— Pygidium and preceding tergites concolorous. Form and epipleurae normal.... 25

25. Form more elongate in male, female shorter. Elytra usually brown or dilute; lateral pale border, when distinctly defined, confined to narrowly explanate margin. Pronotal maculation variable, rarely lacking, usually a more or less distinct broad median vitta. Scutellum usually pale at tip .... (24) *P. ignitus* Fall

— Form broader and less elongate in both sexes. Elytra dark piceous; lateral pale border well defined, exceeding width of explanate margin medially. Pronotum with broad median dark vitta. Scutellum and mesonotal areas dark piceous........ .... (25) *P. consanguineus* LeConte

P. ardens Group

26. Lateral pale border of elytra wider, exceeding width of explanate margin medially. Pronotum longer, usually more narrowly rounded at middle of front margin; lateral margins arcuate, usually feebly converging at hind angles........ .... (26) *P. consimilis* Green, new species

— Lateral pale border of elytra narrow throughout, confined to explanate margin. Pronotum shorter, usually evenly and broadly rounded in front; lateral margins subparallel or feebly diverging to hind angles 27

27. Pronotum with slightly narrower median dark vitta, its lateral margins regular and well defined; pale area each side clear fulvous. Form broader .... (27) *P. carolinus* Green, new species

— Pronotum with broader median dark vitta, its lateral margins somewhat irregular; pale area each side discolored by nubilous brownish or piceous spots, sometimes completely obscured. Form more elongate...... (28) *P. ardens* LeConte

In figure 19 diagrams are presented showing the average body form of three well known species, *P. pyralis, P. consanguineus,* and *P. collustrans.* Reference is made to these diagrams in the species descriptions, as an attempt to convey some idea of the usual body outline. All the species are quite variable in this respect, so that measurement of the length-width ratios would be of little or no value.

In the descriptions that follow, only records confirmed by the author are listed under the distribution captions. For the new species all the specimens studied are included, but only recently examined males are indicated as paratypes. For the previously described species, when represented by very numerous records covering a large territory, only about five are listed from any one state. The present location of the specimens cited is given in parenthesis, abbreviated as shown in the following list:

AMNH — American Museum of Natural History
A & M. Tex — Agricultural and Mechanical College of Texas
ANSP —Academy of Natural Sciences of Philadelphia
CAS — California Academy of Sciences
CM — Carnegie Museum
CNHM — Chicago Natural History Museum
CU — Cornell University
Em. U — Emory University
EL. Aug — Entomological Laboratory at Augusta, Maine
FSPB — Florida State Plant Board

INHS — Illinois Natural History Survey
KSC — Kansas State College
MCZ — Museum of Comparative Zoology
NCDA — North Carolina Department of Agriculture
OSC — Oregon State College
OSM — Ohio State Museum
OSU — Ohio State University
SDSC — South Dakota State College
U.Ark — University of Arkansas
U.Cal — University of California
UCLA—University of California at Los Angeles
U.Del — University of Delaware
U.Fla — University of Florida
U.Kans—University of Kansas
U.Mich — University of Michigan
U.Mo — University of Missouri
UO — University of Ohio
USNM — United States National Museum
Dreisbach — R. R. Dreisbach
Frost — C. A. Frost
Malkin — Borys Malkin
McClay — A. T. McClay

(1) **Photinus texanus** Green, new species

HOLOTYPE. MALE; Brownsville, Texas, October, 1942, collector unknown. In collection of California Academy of Sciences.

Form as in *P. marginellus*. Pronotum with median dark vitta attaining base but not apex, widest in front, narrowest just before base, at middle nearly one-third as wide as convex surface; anterior coarsely punctate area dusky medially. Scutellum and mesonotal areas dark piceous. Elytra dark brownish piceous, sutural bead flavate nearly to scutellum, lateral pale border wider, exceeding width of explanate margin medially, narrowly continuous around apex. Ventral segments 2 to 4 dark piceous, 5 piceous with apical border pale, 6 to 9 pale, the last faintly dusky; pygidium dark piceous.

Eyes large, separated medially above by less than diameter of eye. Disk of pronotum minutely and sparsely punctulate. Epipleurae as in *P. marginellus*. Ventral segments 6 and 7 large, entirely luminous. Aedeagus as in figure 1. Length 6.25 mm.

FEMALE. Alate, similar to male. Eyes smaller, separated by more than diameter of eye. Ventral surface of abdomen dark piceous, segment 5 with apical border narrowly pale medially, segment 6 pale, luminous in median third or more of width, each side sometimes dusky.

VARIATIONS. The pronotal vitta may be uniformly wide throughout its length, or it may be reduced to a triangular spot, widest in front and not quite attaining base. The pale apical border of male ventral segment 5 may be more extensive, extending nearly to base medially. Length 5–7 mm.

DISTRIBUTION. TEXAS. *Brownsville:* holotype and 1 paratype, X–42 (CAS); 1 paratype, VI–5–32, J. O. Martin (CAS); 2 females, V–9–08 (U.Mo); 1 female, V–8–35, D. J. & J. N. Knull (OSU); 1 paratype, VIII–8–37, D. J. & J. N. Knull (OSU); 2 paratypes, one dated V–11–38, C. H. T. Townsend (USNM); 1 paratype, VII, Wickham (USNM). *Cameron County:* 1 paratype, 1 female, IV–4–50, D. J. & J. N. Knull (OSU). *Columbus:* 1 female, Wickham (USNM). *Devils River:* 1 male, V–2–07, Bishop & Pratt (USNM). *Gillespie County:* 1 paratype, VI–11–49, D. J. & J. N. Knull (OSU), *Jackson County:* 1 female, V–22–39, D. J. & J. N. Knull (OSU). *San Juan:* 1 paratype, VI–28–38, L. W. Hepner (U.Kans). *Uvalde:* 1 paratype, VI–15–30, J. O. Martin (CAS). *Victoria:* 1 paratype, IV–16, E. A. Schwarz (USNM). No definite locality: 2 females, coll. C. V. Riley (USNM); 1 paratype, Otto Lugger (CNHM). COAHUILA, MEXICO: 1 paratype, Rancho la Golondrina, Rio Sabinas, *Muzquiz,* VI–28–38, Rollin H. Baker (A &M.Tex.).

This species closely resembles *P. marginellus,* from which it may be distinguished with certainty only by the male genitalia. It is probable that the two species do not occur in the same region. There are no records of *P. marginellus* from Texas, except one example rather dubiously labeled "Texas" only.

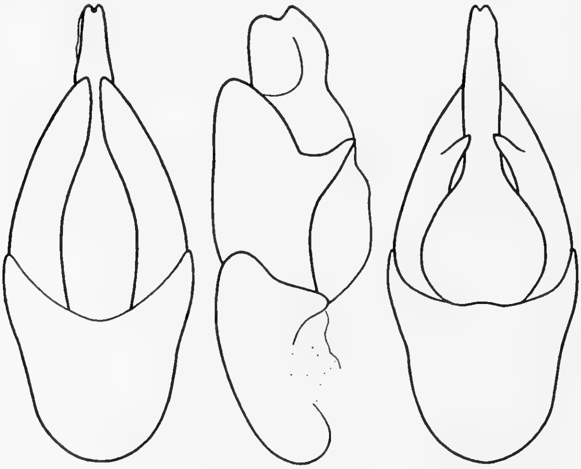


Fig. 1. *Photinus texanus* Green, new species. Paratype; Brownsville, Texas, X-42, E. S. Ross (CAS). Male genitalia: ventral, lateral, and dorsal views, arranged in that order from left to right.

(2) **Photinus immaculatus** Green, new species

HOLOTYPE. MALE; Gillespie County, Texas, VI–23–40, D. J. & J. N. Knull. In collection of Ohio State University.

Form as in *P. marginellus.* Pronotum without median dark spot. Scutellum and mesonotal areas fulvous. Elytra dark piceous brown, sutural bead distinctly flavate in apical half only, lateral pale border wider, confined to explanate margin, narrowly continuous around apex. Ventral segments 2 to 4 dark piceous, 5 to 9 pale; pygidium dark.

Eyes large, separated medially above by less than diameter of eye. Disk of pronotum minutely and sparsely punctulate. Epipleurae as in *P. marginellus.* Ventral segments 6 and 7 large, entirely luminous. Aedeagus as in figure 2, narrowly inflexed edges of tips of lateral lobes piceous, sparsely denticulate. Length 6.25 mm.

FEMALE. Alate, similar to male. Eyes smaller, separated by more than diameter of eye. Ventral surface of abdomen dark piceous, segment 5 with apical border broadly pale except at sides, segment 6 pale, luminous in median third or more of width, each side somewhat dusky basally.

VARIATIONS. Nothing of importance noted. Length 6–7.75 mm.

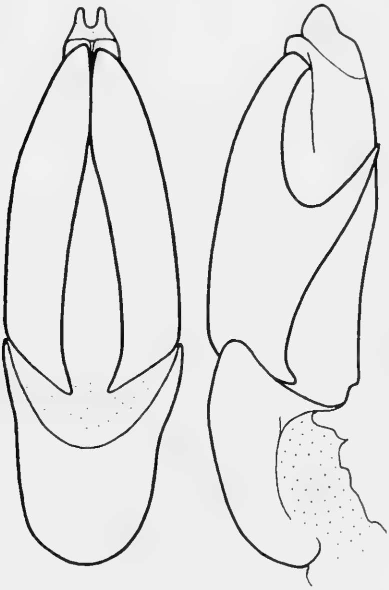


Fig. 2. *Photinus immaculatus* Green, new species. Holotype; Gillespie County, Texas, VI–23–40, D. J. & J. N. Knull (OSU). Male genitalia: ventral, lateral, and dorsal views, arranged in that order from left to right.

DISTRIBUTION. TEXAS. *Gillespie County:* VI–23–40, D. J. & J. N. Knull, holotype, 1 paratype, 3 females (OSU).

It is probable that this species may be distinguished from all other members of Division I by its immaculate pronotum, pale scutellum and mesonotal areas, and normally pigmented elytra. The male genitalia are distinctive, and should be depended upon for identification.

(3) **Photinus cookii** Green, new species

HOLOTYPE. MALE; Crailhope, Kentucky, VII–11–46, Carl Cook. In collection of California Academy of Sciences.

Form as in *P. marginellus*. Pronotum with median dark vitta attaining base and apex, of nearly uniform width throughout, about one-third as wide as base of pronotum. Scutellum and mesonotal areas dark piceous. Elytra piceous black, sutural bead flavate nearly to scutellum, lateral pale border wider, confined to explanate margin, narrowly continuous around apex. Ventral segments 2 to 5 piceous black, 6 to 9 flavate, basal and lateral borders of 6 and lateral borders of 7 piceous, the dark colors indefinitely limited; pygidium dark.

Eyes comparatively small, separated medially above by more than diameter of eye. Disk of pronotum finely and sparsely punctulate. Epipleurae as in *P. marginellus*. Ventral segment 6 subequal in length to 5, 7 slightly longer; light organs not evident. Aedeagus as in figure 3, distal part of lateral lobes and tips of dorsal branches dark piceous. Length 6.75 mm.

FEMALE. Alate, similar to male. Eyes slightly smaller. Ventral sur-

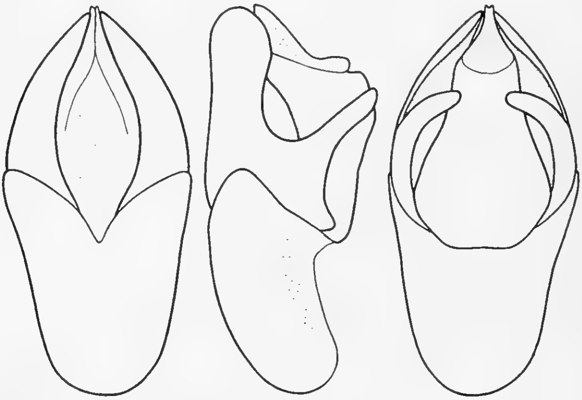


Fig. 3. *Photinus cookii* Green, new species. Paratype; Crailhope, Kentucky, VII–11–46, Carl Cook (CAS). Male genitalia: ventral, lateral, and dorsal views, arranged in that order from left to right.

face of abdomen entirely dark piceous, segments 6 and 8 sometimes with pale maculation.

VARIATIONS. In the male ventral segment 6 varies from largely pale with an indefinite dusky spot at middle of basal border, to entirely black; ventral segment 7 varies from entirely pale to largely dusky with apical border testaceous. In the female the abdomen beneath may be entirely black, or the terminal segment may be partially pale, and segment 6 may be more or less pale medially in the usual position of the luminous area of the female. In both sexes the limits of the dark areas are indefinite or nubilous. The sutural bead of the elytra is sometimes not distinctly flavate, and may be scarcely paler than the adjacent surface. Length 5.25–7.75 mm.

DISTRIBUTION. KENTUCKY. *Crailhope:* holotype, 14 paratypes, 19 females, VII–1 to 13–1946, Carl Cook (CAS); 3 females, VII–23–47, Carl Cook (CAS); 1 paratype, VII–11–46, Carl Cook (Frost). TENNESSEE. *Great Smoky Mountains National Park:* 1 male, Cades Cove, VIII–12, R. R. Dreisbach (Dreisbach). NORTH CAROLINA. *Raleigh:* 3 paratypes, VI–28–35, VII–2–29, VII–7–32, C. S. Brimley (CAS); 1 male, VI–23 (UO). FLORIDA. *Okeechobee:* 1 female, IV–1–37, J. C. Bradley (CU). ILLINOIS. *Elizabethtown:* 2 paratypes, VI–25–32, Ross, Dozier, & Park (INHS). MISSOURI. *St. Louis:* 1 female, VII–17–90, W. M. Gordon (CU). *Arnold:* 1 female, 1 paratype, VIII–23, D. J. & J. N. Knull (OSU). *Roaring River State Park:* 1 paratype, 1 female, VI–15–54, J. W. Green (CAS) TEXAS. *Karnack:* 1 paratype, V–22–51, D. J. & J. N. Knull (OSU). *Bay City:* 1 paratype, 7 females, V–4–53, R. H. Beamer (U.Kans).

This species is named in honor of Carl Cook, who collected a large series at Crailhope, Kentucky, and writes concerning it: "Most of the specimens were taken in the daytime by sweeping grasses and shrubs along small streams. A few, however, were collected while flying at night. None of the examples of this species that I have taken were flashing." This information, together with the reduction in the size of the eyes and of abdominal segments 6 and 7, indicates rather conclusively that *P. cookii* is non-luminous. In certain specimens the texture of the pale areas of ventral segments 6 and 7 suggests that the ability to flash has not been completely eliminated. This species is readily distinguished from all others of Division I by the absence of a pale apical border in ventral segment 5.

(4) **Photinus marginellus** LeConte

Photinus marginellus LeConte, 1851, Acad. Nat. Sci. Philadelphia, Proc. (2), 5:335.
Photinus castus LeConte, same as above. (restored synonymy)

MALE. Color variable, normally pronotum with median dark spot widest in front, not attaining base or apex, sometimes diffusely entering anterior coarsely punctate area. Scutellum dusky, paler at tip, mesonotal areas more or less dusky. Elytra brownish piceous, sutural bead flavate to scutellum, lateral pale border wider, exceeding width of explanate margin medially, rather broadly continuous around apex. Ventral segments 2 to 4 piceous brown, 5 pale with basal border sometimes irregularly maculate, 6 to 9 pale; pygidium pale. Color of dorsal surface varying through progressive stages of dilution to entirely dingy whitish testaceous.

Eyes large, separated medially above by less than diameter of eye. Disk of pronotum minutely and sparsely punctulate. Epipleurae subhorizontal, gradually narrowing from base. Ventral segments 6 and 7 large, entirely luminous. Aedeagus as in figure 4, pale fulvous, tips of lateral lobes usually darker.

FEMALE. Alate, similar to male. Eyes smaller, separated by more than diameter of eye. Ventral segments 2 to 5 piceous brown, 5 with irregular pale apical border, 6 luminous in median third or more of width, 6 to 8 pale, usually with pale brownish maculation.

LENGTH. Both sexes, 6.5–9 mm.

DISTRIBUTION. NEW HAMPSHIRE. *Durham:* VIII–24, VIII–4 (INHS). *Hampton:* VII–20 (EL.Aug). MASSACHUSETTS. *Woods Hole:* VII–18 (CU). *Framingham:* VI–21 to VIII–9 (Frost). *N. Egremont:* VI, VIII (U.Cal). *Monterey:* VI–30 (Frost). *Southboro:* VI–3 (Frost). CONNECTICUT. *Cornwall:* VI–24, VII–13 (Frost). *Litchfield:* VIII–23 (AMNH). STAMFORD: VIII–1 (AMNH). *Lakeville:* VII–14 (Malkin). *S. Norwalk:* VII–10 (AMNH). NEW YORK. *Ithaca:* VI–26 to VIII–22 (CU). *Olcott:* VII–17 to VIII–16 (CU). *Lockport:* VII–24 (CU). *Bear Mountain:* VII–4

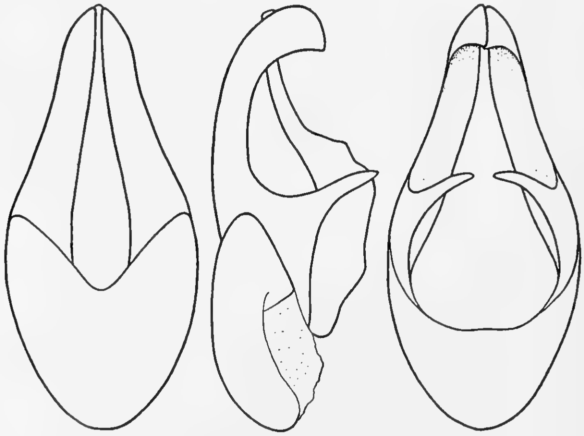


Fig. 4. *Photinus marginellus* LeConte. Easton, Pennsylvania, VI–24–34, J. W. Green (CAS). Male genitalia: ventral, lateral, and dorsal views, arranged in that order from left to right.

to 28 (AMNH). *N. Fairhaven:* VII–1 (CU). Pennsylvania. *Easton:* VI–22 to VII–26, J. W. Green (CAS). *Mt. Pocono:* VII–14, J. W. Green (CAS). *Wyomissing:* VI–19 (McClay). *State College:* VII–23 (Frost). *Pittsburgh:* VI–26 to VII–3 (CAS). New Jersey. *Linwood:* VII–17, J. W. Green (CAS). *New Brunswick:* VI–18 (AMNH). *Ramsey:* VI-29 to VII–31 (AMNH). *Alpine:* VII–25 (AMNH). *Mt. Holly:* VII–4 (Marx). Maryland. *Sparrows Point:* VII–5–34, J. W. Green (CAS). *Odenton:* VII–14 (CU). West Virginia. *Sistersville:* VI–19 (CU). OHIO. *Athens:* VI–23 (UO). *Scisto County:* Roosevelt Game Preserve, VII–20 (UO). *Cleveland:* VII–4 (AMNH). *Delaware County:* VII–21 (OSU). Michigan. *Ionia County:* VII–10–40 (Dreisbach). Indiana. *Cedar L.:* VII–17 (INHS). *Albion:* VII–8–35, H. E. Brown. *Ft. Sheridan:* VIII–30 (Frost). Illinois. *Pittsfield:* VI–6, VII–8 (McClay). *Algonquin:* VII–1 to VIII–8 (INHS). *Monticello:* VII–2 (INHS). *Evanston:* VIII–7 (Marx). *Justice:* VII–23 (INHS). Kentucky. *Quicksand:* VI–25 (CU). *Crailhope:* VI–16–49, Carl Cook (CAS). Tennessee. *Johnson City:* VI–12–51, O. Bryant (CAS). North Carolina. *Black Mountain:* VII–4–40, J. W. Green (CAS). *Southern Pines:* VI–6 (USNM); V–30 (NCDA). *Raleigh:* VI-6 to VII–11 (NCDA). *Cherokee:* VI–28 (UO). *L. Toxaway:* VI–22 (AMNH). Alabama. *Mt. Vernon.* Mississippi. Leakesville: V-23 (CU). *Lucedale:* VI-17 (CU). *Hattiesburg:* VI–28 (AMNH). Wisconsin. *Platteville:* VI–26 (UO). *Milwaukee:* VII–30–89 (AMNH). *Winona* to Stockton: VII–6–28, B. Boland (USNM). Missouri. *St. Charles:* IX–20–01, G. W. Bock (U.Mo). Texas. No definite locality (AMNH). Quebec. *Rouville County:* X–7–02 (U.Mo). Ontario. *St. Cath.:* VI–27 to VII–20, S. D. Hicks.

To confirm the identity of this species the genitalia of LeConte's types at the Museum of Comparative Zoology were examined. The very pale form of *P. marginellus,* uniformly dingy whitish testaceous above, was described as *P. castus* by LeConte, who subsequently reduced it to synonymy. In the Leng Catalogue *P. castus* was again accorded specific rank. Because of the very great interspecific diversity occurring in the male genitalia of this division of *Photinus,* it would be illogical to consider *P. castus* and *P. marginellus,* having identical genitalia, as two distinct species. Possibly *P. castus* is entitled to subspecific standing, as it is found in localities where the pigmented form does not occur. This course has not been followed herein because of the completely intergrading color phases connecting the two extremes. A similar condition is noted in the following species, and also in several species of Division II.

(5) **Photinus curtatus** Green, new species

HOLOTYPE. MALE; Grosse Ile, Wayne County, Michigan, VII–31–50, George Steyskal. In collection of California Academy of Sciences.

Form as in *P. marginellus.* Pronotum with narrowly subtriangular median dark spot, widest in front, scarcely entering anterior coarsely punctate area, narrowing posteriorly, nearly attaining base. Scutellum and mesonotal areas dusky, scutellum paler apically. Elytra brownish piceous, sutural bead flavate to scutellum, lateral pale border wider, exceeding width of explanate margin medially, rather broadly continuous around apex. Ventral segments 2 to 4 piceous brown, 5 pale with basal border irregularly brownish, 6 to 9 pale; pygidium pale.

Eyes large, separated medially above by less than diameter of eye. Disk of pronotum minutely and sparsely punctulate. Epipleurae as in *P. marginellus.* Ventral segments 6 and 7 large, entirely luminous. Aedeagus as in figure 5, pale flavate. Length 7.25 mm.

FEMALE. Alate, similar to male. Eyes smaller, separated by more than diameter of eye. Ventral segments 2 to 5 brownish piceous, 5 with irregular pale apical border, 6 luminous in median third or more of width, 6 to 8 pale, more or less brownish baso-laterally.

VARIATIONS. The pronotal dark spot, usually triangular, may be reduced to a small sublinear maculation, or it may be vittiform and only slightly narrowing posteriorly. The color of the elytra varies from a fully pigmented dark brown to a very dilute brownish gray. Length 6–8 mm.

DISTRIBUTION. New York (extreme western). *Hamburg:* 1 paratype, VI–21–08, M. C. Van Duzee (CAS). *Rapids:* 1 paratype, VII–2–33 (CU). *Woodville:* 2 paratypes, VI–20–38, W. T. M. Forbes (CU). *Lancaster:* 1 paratype, VI–25–46, R. H. Beamer (U.Kans); 2 paratypes, VI–

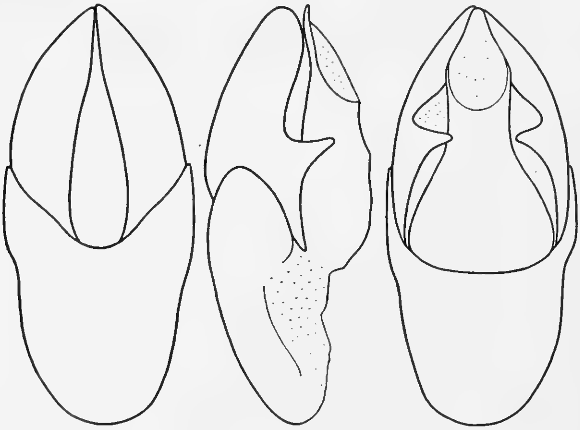


Fig. 5. *Photinus curtatus* Green, new species. Holotype; Gross Ile, Wayne County, Michigan, VII–31–50, Geo. Steyskal (CAS). Male genitalia: ventral, lateral, and dorsal views, arranged in that order from left to right.

28–08, M. C. Van Duzee (CAS); 2 paratypes, M. C. & E. P. Van Duzee (CAS). Ohio. *Columbus:* 2 paratypes, 1 female, VI–27 & 28–51, R. M. Goslin (CAS); large series, VI–27 (OSM). *Delaware County:* 1 paratype, VII–2, D. J. & J. N. Knull (OSU). *Franklin County:* 8 examples, Clinton Township, VII–8 (OSM). Michigan. *Grosse Ile,* Wayne County: holotype, 20 paratypes, 1 female, VII–12 to VIII–1–50, Geo. Steyskal (CAS); 1 paratype, VII–12–50, Geo. Steyskal (Frost). *Detroit:* 1 male, 1 female, VII–20, Summerville. *Oakland County:* 2 paratypes, VII–24–32, A. W. Andrews (CU); 1 male, 1 female, VII–26 (U.Mich). Illinois. *Ft. Sheridan:* 2 paratypes, VIII–12–23, F. Psota (CNHM). *De Kalb County:* 4 paratypes (INHS). *Douville:* 2 paratypes, VII–16–30, Frison & Hottes (INHS). *Putnam County:* 1 paratype, VI–24–32, M. O. Glenn (INHS). *Lilly:* 1 paratype, VI–11–14 (CAS). *Florence:* 1 male, VII–6 (McClay). *Riverside:* 1 male, VII–13 (U.Mich). *Heyworth:* 2 paratypes, VI–24 & 27, Wolcott (USNM). *Peoria:* 3 paratypes, VII–14–23, F. A. McDermott (USNM); 3 paratypes, same data (CAS). *Cairo:* 1 paratype, VII–25, H. S. Barber (USNM). Iowa. *Iowa City,* Wickham: 4 paratypes (U.Mo); 5 paratypes (USNM); 5 paratypes, VII–2 (USNM); 1 paratype, 1 female, VII–21 (USNM); 2 paratypes, VI–25–98 (USNM). *Mt. Pleasant:* 1 paratype, VII–19–28 (USNM). *McGregor:* 1 male, 2 females, VII–15 (U.Mich). No definite locality: 1 male, 1 female (SDSC). South Dakota. *Vermillion:* 2 males, VII–20 & 22 (SDSC). Nebraska. *Malcolm:* 1 paratype, VII–9–09, C. R. Oertel (Frost). *Palmyra:* 1 male, 2 females, VII–3 (McClay). Kansas. *Baldwin:* 1 paratype, 1 female, VI–17–06, J. C. Bridwell (CAS); 1 paratype, VI–7 to 11–06 (CAS); 8 examples, VI–7 to 11–06 (OSC). *Riley County:* 4 paratypes, VII, VII–2, VII–17, Popenoe (USNM); 1 female, VII–10 (CAS); 1 male, VII (KSC). *Topeka:* 2 males, Popenoe (KSC); 2 paratypes, Popenoe, coll. Ashmead (USNM); 1 paratype, Popenoe (CAS). *Leavenworth:* 1 paratype, VII–23–43, M. Y. Marshall (CAS). *Douglas County:* 1 paratype, VI–21–21, Robert Guentert (U.Kans). *Argentine:* 3 paratypes, 1 female, VII–10–06 (U.Mo). Oklahoma. *Major County:* 1 male, VI–26–30, R. D. Bird (CAS).

There are apparently no external characters separating this species from *P. marginellus.* Males are identifiable only by their genitalia, and females by association with the males.

(6) **Photinus floridanus** Fall

Photinus floridanus Fall, 1927, Brooklyn Ent. Soc., Bull., 22:210.

MALE. Form as in *P. marginellus.* Pronotum with median dark vitta usually attaining base but not quite apex, narrowing posteriorly, expanding diffusely in anterior coarsely punctate area. Scutellum and mesonotal areas dark piceous. Elytra dark brownish piceous, sutural bead flavate nearly to scutellum, lateral pale border wider, somewhat exceeding width of explanate margin medially, narrowly continuous around apex. Ventral segments 2 to 4 pale brownish, 5 to 9 pale; pygidium pale, usually with narrow median brownish vitta broadening basally.

Eyes large, separated medially above by less than diameter of eye. Disk of pronotum minutely and sparsely punctulate. Epipleurae as in *P. marginellus.* Ventral segments 6 and 7 large, entirely luminous. Aedeagus as in figure 6.

FEMALE. Alate, similar to male. Eyes smaller, separated by more than diameter of eye. Ventral segments 2 to 4 dark piceous, 5 piceous with pale apical border, 6 pale, luminous in median third or more of width, 7 and 8 pale brownish.

LENGTH. Both sexes, 5.25–6.5 mm.

DISTRIBUTION. FLORIDA. *Gainesville:* Paines Prairie, VII–9 (CU). *Enterprise:* XI–10 (AMNH); V–16, Hubbard & Schwarz (USNM). *Dunedin:* IV–14–16, W. S. Blatchley (CAS); IV– 2 to 14, Mank (CU). *Lake Placid:* Archbold Biol. Station, I–27 (AMNH). *Sanford:* V–4 (AMNH). *Fruitville:* VIII–11–30, R. H. Beamer (U.Kans). *Labelle:* VII–19–48, B. T. McDermott (U.Kans); IV–27 (AMNH). *Crescent City:* IV-22 (AMNH); V-16, Hubbard & Schwarz (USNM). *Lake Okeechobee:* South Bay, V–2 (AMNH). *Paradise Key:* II–22 to III–19 (USNM). *Lake Alfred:* VII–13 & 18, L. Bottimer (USNM). *Biscayne Bay:* (AMNH).

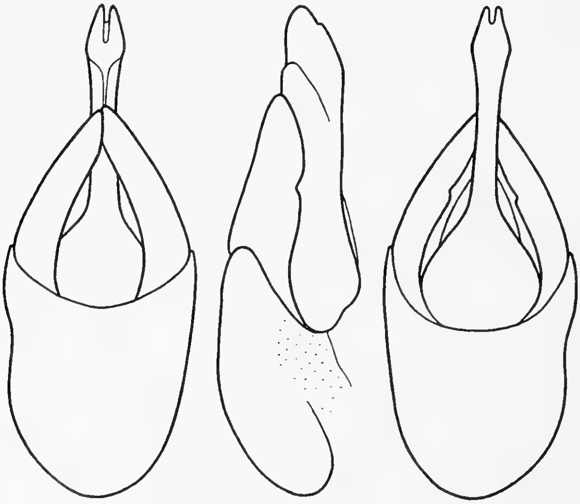


Fig. 6. *Photinus floridanus* Fall. Lake Alfred, Florida, VII–18–28, L. Bottimer, (USNM). Male genitalia: ventral, lateral, and dorsal views, arranged in that order from left to right.

(7) **Photinus sabulosus** Green, new species

HOLOTYPE. MALE; Baltimore, Maryland, VII–21, F. E. Blaisdell. In collection of California Academy of Sciences.

Form as in *P. marginellus*. Pronotum with triangular median dark spot, widest in front where it is about half as wide as convex disk, diffusely entering anterior coarsely punctate area, narrowing posteriorly, nearly attaining base. Scutellum dark piceous, mesonotal areas somewhat paler. Elytra piceous black, sutural bead flavate to scutellum, lateral pale border wider, exceeding width of explanate margin medially, rather broadly continuous around apex. Ventral segments 2 to 4 brownish fuscous, somewhat mottled, 5 to 9 pale; pygidium mahogany brown medially, sides pale.

Eyes large, separated medially above by less than diameter of eye. Disk of pronotum minutely and sparsely punctulate. Epipleurae as in *P. marginellus*. Ventral segments 6 and 7 large, entirely luminous. Pygidium densely and irregularly punctate, punctures in part somewhat elongate and open posteriorly; surface strongly longitudinally humped or roof-shaped; apex broadly truncate and bisinuate, produced at middle in a feeble lobe. Aedeagus as in figure 7, lateral lobes densely sclerotized, black except basally. Length 7.5 mm.

FEMALE. Alate, similar to male. Eyes smaller, separated by more than diameter of eye. Ventral segments piceous brown, 5 largely pale medially, 6 luminous in median third or more of width, more or less pale each side. Pygidium narrowly rounded at apex, not abnormally elevated

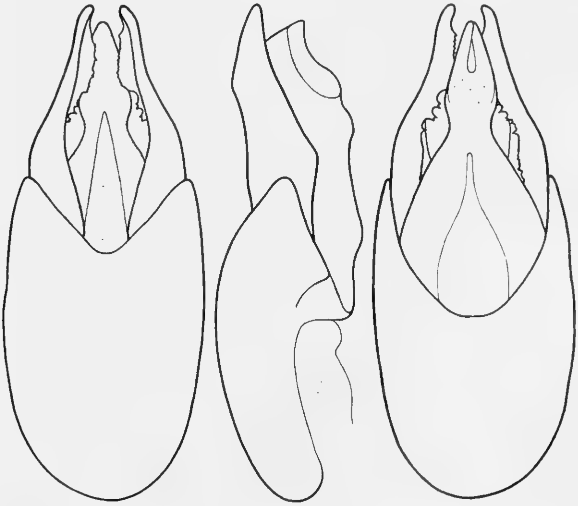


Fig. 7. *Photinus sabulosus* Green, new species. Holotype; Baltimore, Maryland, VII–21, F. E. Blaisdell (CAS). Male genitalia: ventral, lateral, and dorsal views, arranged in that order from left to right.

longitudinally, punctation similar to male, less dense except along apical and lateral borders.

VARIATIONS. The pronotal spot may be vittiform, narrowing only slightly posteriorly and attaining the basal margin, or it may be reduced to a pale brownish infuscation. The color of the elytra varies in being occasionally somewhat paler. Length 6–7.5 mm.

DISTRIBUTION. NEW YORK. *Ithaca:* 2 females, VII–15 & 26–90 (CU); 1 paratype, *Butternut Creek:* VII–21–17, H. Dietrich (CU). PENNSYLVANIA. *Delaware County:* 1 paratype, VIII–2, W. J. Gerhard (CNHM). *Allegheny County:* E. A. Klages: 1 paratype, 3 females (CAS); 1 paratype, 3 females (CU); 1 paratype, 2 females, VI–11 (CU); 2 females, VII–18–29 (CU). *Allegheny:* 2 paratypes, J. B. Smith (USNM). *Ellwood City:* 1 paratype, VII–16–24 (CAS). *Hummelstown:* 2 paratypes, 1 female, VI–26–33 (OSU); 1 paratype, VII–5 (OSU); 1 female, VII–15 (OSU). *Lewisburg:* 1 paratype, VI–24–44, H. S. Barber (USNM). *Glenside:* 3 paratypes, VI–17 & 24–06, G. M. Greene (USNM). *Pequea:* 2 paratypes, IX–1–24, H. S. Barber (USNM). *Pittsburgh:* 1 paratype, VI–30 (CAS). *Jeanette:* 5 examples, VI–17 (OSC). *No definite locality:* 1 male, 3 females (SDSC); 1 paratype, 2 females (U.Mo); 1 paratype, 1 female, VI–17, H. G. Klages (CAS). NEW JERSEY. *Fort Lee:* 1 male, VI–22–39 (Malkin). *Englewood:* 1 female, VII–25–20, E. D. Quirsfeld (CU). MARYLAND. *Plummers Island:* 1 female, VI–29–13 (INHS); 1 paratype, VI–28–05, H. S. Barber (CAS); 2 paratypes, VI–29–19, VI–27–05, H. S. Barber (USNM). *Baltimore:* holotype, 7 paratypes, 4 females, VII–2 to 21–09, F. E. Blaisdell (CAS); 1 paratype, VII–6–09, F. E. Blaisdell (Frost). *Cabin John Bridge:* 1 female, VI–23–29, J. C. Bridwell (USNM). *Priest Bridge:* 1 female, VII–31–29, H. S. Barber (USNM). *Beltsville:* 1 female, VII–30–32, H. S. Barber (USNM). *Bethesda:* 1 paratype, VII–8–51, D. W. Boddy (Malkin). *Glen Echo:* VI–23 & 30–29, Bridwell, 7 paratypes, 6 females (USNM); 1 paratype (CAS); 1 paratype (Frost). *Berwyn:* VII–22 & 31–27, A. B. Gahan, 9 paratypes (USNM); 1 paratype (CAS). DISTRICT OF COLUMBIA. *Washington:* 2 paratypes, VII–4 & 5, Hubbard & Schwarz (USNM); 7 paratypes, VII–19–26, H. S. Barber (USNM); 1 paratype, VII–13–30, J. C. Bridwell (USNM); 2 paratypes, Rock Creek Park, VIII–8–28, H. S. Barber (USNM). VIRGINIA. *Nelson County:* 1 female, VII–5–25, W. Robinson (USNM). *Buffalo Creek:* 1 paratype, VII–5–27, Chamberlain (CU). WEST VIRGINIA. W. Sulphur*:* 1 paratype, VII–3–12, W. Robinson (USNM). *Berkeley:* 1 paratype, Hubbard & Schwarz (USNM). NORTH CAROLINA. *Raleigh:* 3 paratypes, VI–30–25, C. S. Brimley (CAS); 1 female, VI–15–22, C. S. Brimley (CAS). OHIO. *Athens,* W. C. Stehr*:* 2 paratypes, VII–9–34 (CAS); 1 paratype, VI–30–34 (CAS); 1 female, VI–20–34 (CAS); 5 examples, VI–20 to VIII–9 (UO). *Athens County,*

W. C. Stehr: 1 female, Canaan Township, VII–24–47 (CAS); 1 female, Lodi Township, VI–26–47 (CAS); 2 examples, Lodi Township, VI–23 (UO); 3 examples, The Plains, VI–19 & 20 (UO). *Chillicothe:* 1 female, VI–24 (OSM). *Buckeye Lake:* 1 female, VIII–3 (OSM). *Delaware County:* 1 paratype, VIII–2, D. J. & J. N. Knull (OSU). *Green County:* 1 paratype, VI–8–50, D. J. & J. N. Knull (OSU). *Scioto County:* D. J. & J. N. Knull: 1 female, VI–17–44 (CAS); 2 females, VI–10 & 17–44 (OSU). *Hocking County:* D. J. & J. N. Knull, 1 paratype, VII–2 (CAS); 3 paratypes, 3 females, VI–20, VI–24, VII–2 (OSU). *Shawnee Forest:* 1 female, VI–9 (OSU). *Pomeroy,* Meigs County: 1 example, VI–29 (UO). *Zaleski,* Lake Hope; 3 females, VI–22, Ralph Leonard (UO). Illinois. *Dubois:* 1 female, VII–3–09 (INHS). Kentucky. *Livingston:* 1 paratype, VI–17, Hubbard & Schwarz (USNM). Tennessee. *Elmwood:* 3 paratypes, 1 female, V, Corse (U.Mo). *Nashville:* 1 paratype, VI–23–93, H. Soltau (USNM). Mississippi. *Lucedale:* 4 paratypes, 1 female, V–11 to 28, H. Dietrich (CU).

Males of *P. sabulosus* are easily distinguished from all related species by the strongly roof-shaped pygidium. In the female the pygidium is also characteristic in being of a darker color and more strongly sclerotized than usual, and with the modified punctation as described above.

(8) **Photinus acuminatus** Green, new species

HOLOTYPE. MALE; base of Mt. Pisgah, North Carolina, VII–14–1939, D. L. Wray. In collection of California Academy of Sciences.

Form distinctly broader than in *P. marginellus.* Pronotum with broad

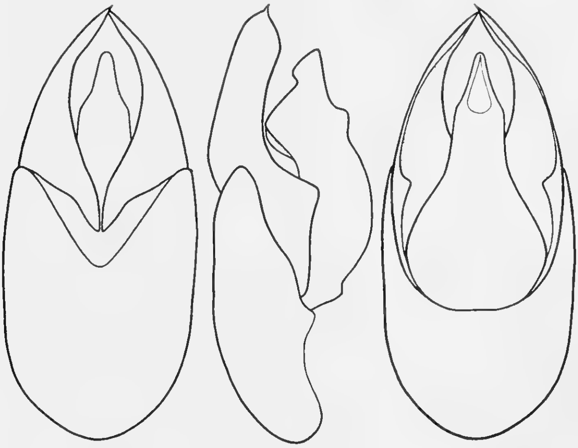


Fig. 8. *Photinus acuminatus* Green, new species. Holotype; Base of Mt. Pisgah, North Carolina, VII–14–39, D. L. Wray (CAS). Male genitalia: ventral, lateral, and dorsal views, arranged in that order from left to right.

dark median vitta attaining base and diffusing in anterior coarsely punctate area without reaching apex, widest in front where it slightly exceeds half the width of convex disk, feebly narrowing posteriorly to near base, then expanding. Scutellum and mesonotal areas dark piceous. Elytra dark piceous brown, sutural bead flavate nearly to scutellum, lateral pale border wider, exceeding width of explanate margin medially, rather broadly continuous around apex. Ventral segments 2 to 4 dark piceous, 5 to 9 pale; pygidium dark with sides indistinctly paler.

Eyes large, separated medially above by less than diameter of eye. Disk of pronotum minutely and sparsely punctulate. Epipleurae as in *P. marginellus*. Ventral segments 6 and 7 large, entirely luminous. Aedeagus as in figure 8, pale fulvous. Length 7.5 mm.

FEMALE. Alate, similar to male. Eyes smaller, separated by more than diameter of eye. Pronotal vitta narrower and somewhat paler. Ventral segments 2 to 4 piceous brown, 5 pale fulvous with irregular darker maculation baso-laterally and with apical border whitish testaceous, 6 entirely whitish testaceous, luminous in median third or more of width, 7 and 8 pale fulvous. Length 8.5 mm.

DISTRIBUTION. NORTH CAROLINA. Base of Mt. Pisgah, holotype. FLORIDA. *Newberry:* V–27–1927, M. D. Leonard, 1 female (CU).

This species looks quite unlike the other members of Division I. It more nearly resembles a small example of *P. consanguineus*, being similar to that species in its broader shape, wide pronotal vitta, and wide lateral pale border of the elytra. At present it is represented only by the unique male and female examples above described.

(9) **Photinus pyralis** (Linné)

Lampyris pyralis Linné, 1767, Systema Naturae, ed. 12, 2:644.
Lampyris rosata Germar, 1824, Ins. Nov., p. 62.
Lampyris centrata Say, 1825, Acad. Nat. Sci. Philadelphia, Jour., 5:162.
Photinus benignus LeConte, 1881, Amer. Ent. Soc., Trans., 9:35 (new synonymy).

MALE. Form as shown in figure 19. Pronotum with median dark spot usually not attaining base and not entering anterior coarsely punctate area except sometimes diffusely; dark spot variable, usually narrowing posteriorly, sometimes much reduced and lightly colored, or absent altogether. Scutellum and mesonotal areas fulvous. Elytra usually dark piceous, varying to brownish, sutural bead fulvous, pale lateral border wider, not or only slightly exceeding width of explanate margin, narrowly continuous around apex. Ventral segments 2 to 4 dark piceous or brown, 5 piceous with broad pale apical border, this sometimes extending to base at sides, 6 to 9 pale; pygidium usually with sides broadly pale leaving a roughly T-shaped median dark area.

Head not or feebly concave between eyes, surface smooth with simple punctulation. Eyes large, separated medially above by less than diameter of eye. Mandibles stouter, as compared with other species of Division II. Disk of pronotum sparsely and minutely punctulate, with or without impressed median longitudinal line. Epipleurae distinct, narrow postbasal part much inflexed, attaining luminous segments. Ventral segments strongly transversely convex, 6 and 7 large, entirely luminous; apex of pygidium narrowly rounded. Aedeagus as in figure 9.

FEMALE. Alate, similar to male. Eyes smaller, separated by more than diameter of eye. Ventral segment 5 with very narrow pale border, sometimes scarcely evident, 6 to 8 pale brownish, 6 pale and luminous in median third or more of width, 7 and sides of 6 sometimes darker piceous; pygidium usually abruptly paler than preceding tergites.

LENGTH. Both sexes, 9–15 mm.

DISTRIBUTION. New York (southern); Pennsylvania; Ohio; Indiana; Illinois; New Jersey; Maryland; Virginia; West Virginia; Kentucky; Tennessee; North Carolina; Georgia; Florida; Alabama; Mississippi; Louisiana; Arkansas; Missouri; South Dakota; Nebraska; Kansas; Oklahoma; Texas. Also the following, perhaps accidental introductions: Colorado, no definite locality, C. V. Riley collection (USNM); Arizona, Phoenix, VI–2–42, E. S. Ross (CAS).

This abundant species, distributed throughout an extensive territory, is naturally subject to some variation. LeConte separated *P. benignus* from *P. pyralis* on insignificant and variable characters that do not justify its

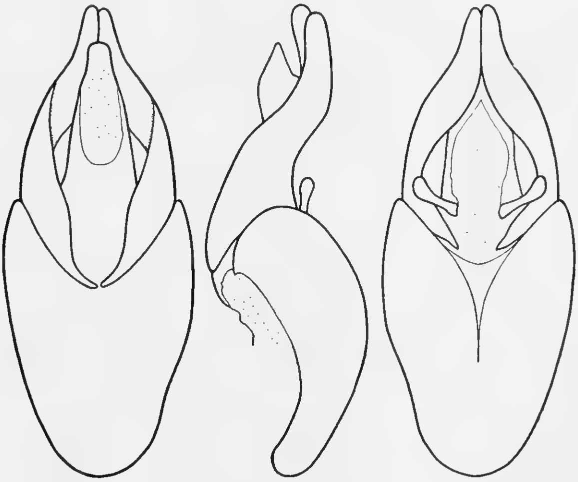


Fig. 9. *Photinus pyralis* (Linné). Johnson City, Tennessee, VI–12–51, Bryant (CAS). Male genitalia, dorsal, lateral, and ventral views, arranged in that order from left to right.

retention as a named taxonomic unit. In the Brownsville region of Texas there is developing an incipient race characterized by a smaller average size, shorter antennae, dusky scutellum, entirely dark pygidium, and slightly more acutely rounded elytral apices. Not one of these distinctions is as yet sufficiently stabilized to permit an accurate segregation of this form. A most unusual variant, perhaps an abnormal specimen, is a male from Uvalde, Texas, in the collection of the California Academy of Sciences. It is rather broader than is normal for *P. pyralis;* the pronotum, scutellum, and mesonotal areas are clear fulvous, the pronotal dark spot totally lacking; the elytra are entirely black, the explanate lateral margins only slightly less dark; and the pale apical border of ventral segment 5 is very feebly indicated.

(10) **Photinus australis** Green, new species

HOLOTYPE. MALE. Snead, Florida, VI–15–51, Price, Beamer, and Weed. In collection of University of Kansas.

Form less elongate than in *P. pyralis.* Pronotum with black median vitta of nearly uniform width throughout, attaining base but not apex, expanding diffusely in anterior coarsely punctate area. Scutellum fulvous, mesonotal areas dusky. Elytra dark piceous, nearly black, sutural bead fulvous, pale lateral border somewhat wider than explanate margin, of nearly uniform width and rather sharply defined internally from humerus to apical third, thence narrow and poorly defined, narrowly continuous around apex. Ventral segments 2 to 5 fuscous, each with a narrow fulvous

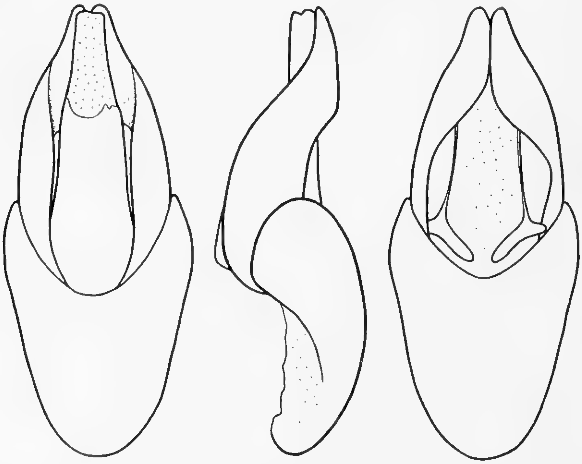


Fig. 10. *Photinus australis* Green, new species. Paratype; N. Wilkesboro, North Carolina, VII–34, F. Perlmutter (CAS). Male genitalia: dorsal, lateral, and ventral views, arranged in that order from left to right.

submedian fascia nubilously defined, surface posterior to fascia largely pale in segment 4 and entirely pale in segment 5, segments 6 to 9 pale; pygidium with sides broadly pale.

Head concave between eyes, surface roughened with irregular granulose punctation; eyes large, separated medially above by less than diameter of eye, their inner margins distinctly converging anteriorly; mandibles slender. Disk of pronotum minutely and sparsely punctulate. Epipleurae narrow except at base, strongly inflexed, attaining abdomen. Ventral segments 6 and 7 large, entirely luminous. Aedeagus as in figure 10. Length 8 mm.

FEMALE. Alate, similar to male. Head not concave between eyes but with similar granulose punctation; eyes smaller, separated by more than diameter of eye. Pronotal vitta broader, narrowed near base. Ventral segments 2 to 5 piceous brown, 5 with broad pale apical border, 6 pale, more or less fuscous each side, luminous in median third of width, 7 and 8 tinged with brown.

VARIATIONS. The pronotal vitta may not quite attain the basal margin, varying in color from black to pale brown. The scutellum and mesonotal areas may be entirely pale, or the base of the scutellum and adjoining area may be dusky. Ventral segments 2 to 4 of the male may be definitely pale only at the sides, or with both apical and lateral borders pale. Length 6.5–10.25 mm.

DISTRIBUTION. Indiana. *Vincennes:* 2 males, VII–11 (U.Mich). Illinois. *Dubois:* 1 paratype, VII–2–09 (INHS). North Carolina. *N. Wilkesboro:* 1 paratype, VII–2–34, E. Perlmutter (CAS). Georgia. *Atlanta:* 1 paratype, VI–24–38, P. W. Fattig (CAS); 1 paratype, VII–13–40, P. W. Fattig (CAS); 1 female, VII–8–37, P. W. Fattig (CAS); 1 female, VII–16–47, P. W. Fattig (USNM). *Ellijay:* 1 paratype, VII–20–45, P. W. Fattig (CAS). Florida. *Snead:* holotype, 3 paratypes, VI–15–51, Price, Beamers, & Weed (U.Kans); 2 paratypes, same data (CAS). Alabama. *Cleburne County:* 1 male, Summit of Mt. Cheaha, VII–5 (U.Mich). Mississippi. *Hattiesburg:* 3 paratypes, Camp Shelby, VII–7 & 10, C. D. Michener (AMNH). *Meridian:* 1 paratype, VII–12–95, H. Soltau (USNM). Missouri. *Cameron:* 1 male, VII–4 (McClay). *Jefferson City:* 1 male, VII–18 (W. W. Dowdy, Lincoln University).

The principal characters separating both sexes of *P. australis* from *P. pyralis* and *P. scintillans* are summarized as follows:

Males of *P. australis* differ from *P. pyralis* in their smaller average size and less elongate form; larger eyes with their inner margins above more definitely converging anteriorly; smaller and more slender mandibles; more approximate antennae; the head concave between the eyes with the surface subgranulosely punctate; and ventral segments 2 to 4 not totally dark piceous.

Females of *P. australis* differ from *P. pyralis* in their smaller and more slender mandibles; and the subgranulose punctation of the head between the eyes.

Males of *P. australis* differ from *P. scintillans* in their larger average size; larger eyes with their inner margins above more definitely converging anteriorly; wider epipleurae; more or less fuscous or piceous ventral segments 2 to 4; and in having the dorsal surface of the median lobe of the aedeagus membraneous in about distal third.

Females of *P. australis* differ from *P. scintillans* in not being brachypterous.

(11) **Photinus scintillans** (Say)

Lampyris scintillans Say, 1825, Acad. Nat. Sci. Philadelphia, Jour., 5:163.

MALE. Form as in *P. marginellus*. Pronotum with median brownish spot about one-third to one-fourth as wide as convex disk, widest in front and narrowing posteriorly, usually not attaining base or apex. Scutellum pale with base more or less dusky, rarely entirely dark; mesonotal areas pale. Elytra dilute reddish brown, varying to darker piceous, sutural bead flavate, lateral pale border confined nearly to explanate margin, well defined only in darker specimens. Ventral surface of abdomen entirely pale, rarely segments 2 to 4 are faintly darker.

Head concave between eyes, surface roughened with irregular granulose

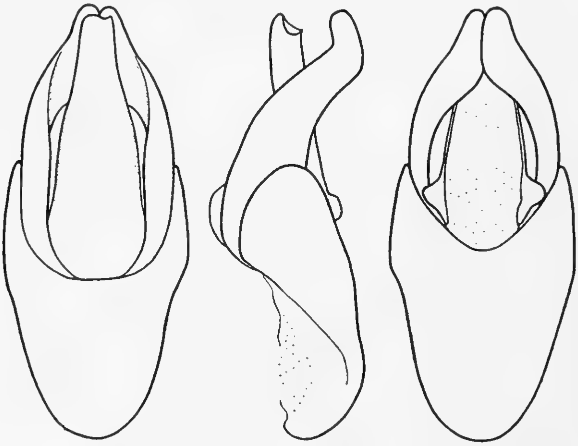


Fig. 11. *Photinus scintillans* (Say). Easton, Pennsylvania, VI–13–34, J. W. Green (CAS). Male genitalia: dorsal, lateral, and ventral views, arranged in that order from left to right.

punctation; eyes large, separated medially above by less than diameter of eye. Disk of pronotum finely and sparsely punctulate, median line distinctly impressed, at least in part. Epipleurae very narrow except at base, scarcely attaining metacoxae. Ventral segments 6 and 7 large, entirely luminous. Aedeagus as in figure 11.

FEMALE. Dissimilar, brachypterous, texture firm. Form compact, abdomen usually somewhat inflated and distinctly wider than elytra. Eyes smaller, separated by about diameter of eye. Elytra varying from one-fourth longer to nearly twice as long as pronotum, strongly dehiscent from scutellum. Ventral segment 6 luminous in median third or more of width. Color pattern as in male.

LENGTH. Both sexes, 6.5–8.5 mm.

DISTRIBUTION. New York. *New York:* Van Cortland Park, VI–27–40 (Malkin). *Staten Island:* (AMNH). Pennsylvania. *Easton:* VI–7 to VIII–27, mostly VI (CAS). *York County:* Washington Township, VII–11–53, P. J. Spangler (CAS); Detters Mill, VI–9–49, P. J. Spangler (U.Mo & CAS). *Lewisburg:* VI–24–44, H. S. Barber (USNM). *Allegheny County:* VI–11, E. A. Klages (CU). *Hummelstown:* VI–24 & VII–10 (OSU). *Bethlehem:* VI–01 (CNHM). *Lenhartsville:* VII–8 (AMNH). *Wyomissing:* VI–21 (McClay). New Jersey. *Newark:* VI–10 (AMNH). *New Brunswick:* VI–19 (AMNH). *Ramsey:* VI–29, VII–6 (AMNH). *Boonton:* VI–20–01, G. M. Greene (USNM). *Alpine:* VII–9–48, J. G. Rozen (U.Cal). Maryland. *Glen Echo:* VI–23–29, J. C. Bridwell (USNM). *Plummers Island:* VII–23–20, H. S. Barber (USNM); VI–6–19 (CNHM). *Baltimore:* VII–6 & 12–09, F. E. Blaisdell (CAS). District of Columbia. *Washington:* VII–13, Hubbard & Schwarz (USNM). Delaware. Newark: V–28 (INHS). *Wilmington:* V–5–38, F. A. McDermott (USNM). Virginia. *Great Falls:* VI–6–41 (Malkin). *Black Pond:* VII–1–26, H. S. Barber (USNM).

This species bears a close superficial resemblance to the more abundant and much more widely distributed *P. marginellus*, and the two have often been found indiscriminately mixed in collections. External differences readily separating the males, of specimens in good condition, are as follows: In *P. scintillans* the head is concave between the eyes with the surface irregularly granulose-punctate; the underside of the abdomen is entirely pale; the exposed part of the last ventral segment is narrowly subtriangular; and the epipleurae are distinctly visible only basally. In *P. marginellus* the head is flat between the eyes with the surface not granulose; the basal segments of the abdomen beneath are brown or fuscous; the exposed part of the last ventral segment is more broadly subtriangular, nearly equilateral; and the epipleurae are wider, less abruptly narrowed basally, and quite distinct as far as the luminous segments.

(12) **Photinus brimleyi** Green, new species

Photinus brimleyi Wray not Green, *nomen nudum*, 1950, North Carolina Dept. Agric., 2nd Sup. Ins. of N. C., p. 16.

HOLOTYPE. Male. Crailhope, Kentucky, VII–8–46, Carl Cook. In collection of California Academy of Sciences.

Form similar to *P. consanguineus.* Pronotum with median dark spot not attaining base or apex, narrowing posteriorly, abruptly wider in front, diffusely entering anterior coarsely punctate area. Scutellum and mesonotal areas pale fulvous. Elytra dark brownish piceous, sutural bead fulvous, lateral pale border wider, distinctly exceeding width of explanate margin medially, rather broadly continuous around apex; epipleurae entirely pale fulvous. Ventral segments 2 to 5 piceous black, 6 to 9 pale; pygidium dark.

Eyes large, separated medially above by less than diameter of eye. Disk of pronotum finely and sparsely punctulate, impressed median longitudinal line defined by convexity of surface each side. Epipleurae narrow except at base, attaining abdomen. Ventral segments 6 and 7 large, entirely luminous. Aedeagus as in figure 12, pale fulvous, lateral lobes darker except at base and apex. Length 10.5 mm.

FEMALE. Dissimilar, brachypterous. Body elongate, of soft larval texture, pale fulvo-testaceous throughout, elytra basally and pronotum anteriorly somewhat darker, pronotum without median dark spot, elytra without paler borders. Eyes smaller, separated by slightly more than diameter of eye. Elytra one-third longer than pronotum, attaining basal margin

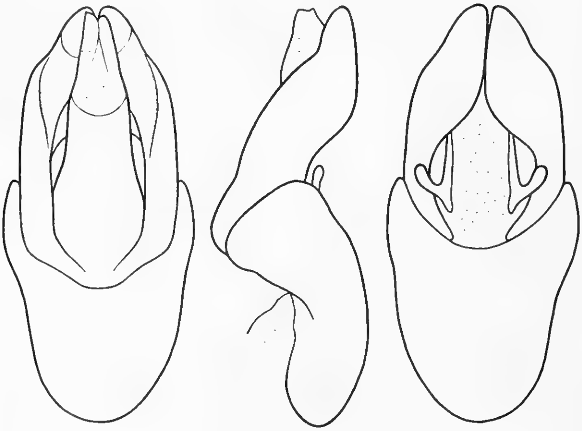


Fig. 12. *Photinus brimleyi* Green, new species. Holotype; Crailhope, Kentucky, VII–8–46, Carl Cook (CAS). Male genitalia: dorsal, lateral, and ventral views, arranged in that order from left to right.

of tergite 2, strongly dehiscent from near scutellum. Abdomen above finely and densely granulate-punctate. Ventral segment 6 luminous in median third of width; pygidium narrowly rounded at apex. A single example collected at Crailhope, Kentucky, by Carl Cook, VII–2–49, in collection of California Academy of Sciences. Length 11.75 mm.

VARIATIONS. The pronotal spot varies as usual in size, and in color from nearly black to pale brown, rarely entirely lacking. The median longitudinal impression of the pronotum varies from quite deep to shallow, or nearly obliterated. The color of the elytra varies to a somewhat dilute brownish piceous, with the sutural pale border expanding slightly toward base. In one specimen from the type locality, apparently conspecific, the pronotal spot is broadly vittiform, as in *P. consanguineus,* nearly reaching the basal margin. This specimen is also anomalous in having the lateral pale border of the elytra confined nearly to the explanate margin. Length 8–12.5 mm.

DISTRIBUTION. KENTUCKY. *Crailhope:* holotype, 167 paratypes, 1 female, V–14 to VIII–21, Carl Cook (CAS); 30 paratypes, same data (U.Kans, AMNH, OSU, INHS, USNM, CU, ANSP, CNHM, CM, Frost, Malkin). NORTH CAROLINA. *Hendersonville:* 2 males, VI–1907, F. Sherman (CAS); 1 male (NCDA). GEORGIA. *Rabun County:* 4 males, VII (AMNH). *Fort Mountain:* 1 male, VII–9–37, P. W. Fattig (CAS). ARKANSAS. *Cove:* 7 males, VI–20–38, L. W. Hepner (U.Kans). *Scott County:* 3 males, VIII–24–28, R. H. Beamer (U.Kans).

The author is greatly indebted to Carl Cook, of Crailhope, Kentucky, for the large series of paratypes of this species, and for the female specimen described above. A second female received from Mr. Cook was sent to the late H. S. Barber, who at that time expected to revise the U. S. species. The first specimens of *P. brimleyi* were sent in by the late C. S. Brimley, of the North Carolina Department of Agriculture. Examples returned to him with the manuscript name "*Photinus brimleyi*" were responsible for the *nomen nudum* appearing in the second supplement of the Insects of North Carolina (Wray, 1950). It is probable that additional species related to *P. brimleyi* may occur in the western limits of its range. Inadequate material from Arkansas suggesting this possibility has been found in several of the collections examined.

DIAGNOSTIC CHARACTERS. Male: form similar to *P. consanguineus;* ventral segments 2 to 5 entirely dark piceous; genitalia of the *P. punctulatus* group; disk of pronotum minutely and sparsely punctulate; lateral pale border of elytra much wider than explanate margin; epipleurae entirely fulvous; scutellum and mesonotal areas fulvous; pygidium and preceding tergites concolorous, dark piceous. Female brachypterous.

(13) **Photinus punctulatus** LeConte

Photinus punctulatus LeConte, 1851, Acad. Nat. Sci. Philadelphia, Proc., (2), 5:335.

MALE. Form similar to *P. pryalis.* Pronotum with central dark spot narrowing posteriorly, nearly attaining base. Scutellum usually piceous or black with pale apex, varying to entirely pale; mesonotal areas fulvous. Elytra dark piceous or black, sutural bead and narrowly explanate side margin pale fulvous, pale color more or less distinctly continuous around apex; epipleurae fuscous basally. Ventral segments 2 to 5 piceous black, 6 to 9 pale; pygidium abruptly pale flavate, preceding tergites dark piceous.

Eyes large, separated medially above by less than diameter of eye. Disk of pronotum closely punctate, punctures small, impressed, separated by about their diameters, sometimes finer on pale areas; median longitudinal line narrow and deeply impressed. Epipleurae very narrow except at base, scarcely attaining abdomen. Ventral segments 6 and 7 large, entirely luminous. Aedeagus similar in structure to figure 12.

FEMALE. Dissimilar, elongate, brachypterous; texture firm. Eyes smaller, separated by more than diameter of eye. Antennae shorter. Elytra very short, subequal in length to pronotum, not extending beyond first abdominal tergite, strongly dehiscent from near scutellum. Pronotum and elytra colored as in male; abdomen above piceous black or brown, lateral and sometimes apical borders of tergites more or less rufous, pygidium pale. Ventral segment 6 pale and luminous in median third or more of width.

LENGTH. Both sexes, 8:5–11 mm.

DISTRIBUTION. ILLINOIS. *Pittsfield:* VI–11–47, VI–8–48, B. Caldwell (CAS); VI–20–52, B. Caldwell (U.Cal); IV–3 to VIII–4 (McClay). *Peoria:* VI–25–24, F. A. McDermott (USNM); VII–1 (INHS). *Springfield:* VII–2–38, J. W. Green (CAS). *Havana:* V–21–32, Ross & Mohr (CAS, INHS). *Normal:* V–28 (INHS). *Bloomington:* VI–1 (INHS). IOWA. *Iowa City:* VI–1–37, J. P. E. Morrison (USNM); VI–10 and VII–20, Wickham (USNM). MISSOURI. *Sedalia:* V–17–39, W. L. Wright (U.Mo). *Yarrow:* V–13–50, Frank Weber (U.Mo). *Lake of Ozarks:* V–6–50, V. D. Goodnight (U.Mo). KANSAS. *Lawrence:* 900 ft., E. S. Tucker (U.Kans). *Oskaloosa:* V–11–49, R. H. Beamer (U.Kans). *Atchison:* V (USNM). *Topeka:* Popenoe (KSC). *Riley County:* V–21, F. Marlatt (CAS). OKLAHOMA. *Comanche County:* Wichita Mountains Game Refuge, F. B. McMurry (USNM). TEXAS. *Nacogdoches:* IV–6 (AMNH).

This species is one of the most easily recognized of the Nearctic fauna. The pale pygidium, contrasting sharply with the preceding dark piceous tergites, is duplicated only in the narrowly elongate *P. lineellus,* occurring in the extreme Southeast. The distinctly punctate pronotum is a unique characteristic of *P. punctulatus,* although it is approached somewhat in *P. frosti.* In the latter species the pygidium and preceding tergites are concolorous dark piceous.

(14) **Photinus tenuicinctus** Green, new species

HOLOTYPE. MALE; Fayetteville, Washington County, Arkansas, VII–14–53, L. H. Rolston. In collection of California Academy of Sciences.

Form similar to *P. consanguineus.* Pronotum with broad median dark spot narrowing posteriorly and nearly attaining base, diffusing in anterior punctate area without reaching apex. Base of scutellum and mesonotal areas dark piceous, scutellum pale in about apical half. Elytra dark brownish piceous, sutural bead flavate, lateral pale border not wider, confined to outer edge of explanate margin, narrowly continuous around apex; epipleurae dusky throughout. Ventral segments 2 to 5 piceous black, 6 to 9 pale; pygidium dark.

Eyes large, separated medially above by less than diameter of eye. Disk of pronotum finely and rather closely punctulate, punctures more or less granulate, especially on pale areas; impressed median longitudinal line defined by convexity of surface each side. Epipleurae narrow except at base, attaining abdomen. Ventral segments 6 and 7 large, entirely luminous. Aedeagus as in figure 13, pale fulvous, lateral lobes mostly dark piceous. Length 11.5 mm.

FEMALE. Unknown, probably brachypterous.

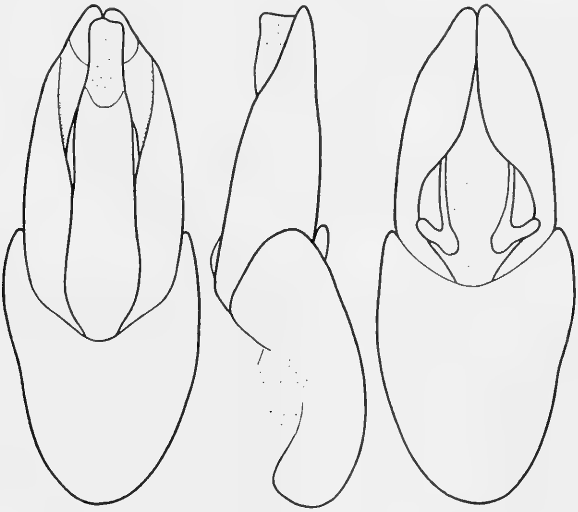


Fig. 13. *Photinus tenuicinctus* Green, new species. Paratype; Mt. Sequoyah, Washington County, Arkansas, VI–20–38, M. W. Sanderson (CAS). Male genitalia: dorsal, lateral, and ventral views, arranged in that order from left to right.

VARIATIONS. The pronotal vitta varies from one-third to three-fifths as wide as the convex disk, and is usually broad at the basal extremity, somewhat is in *P. consanguineus.* The punctulation of the pronotal disk may be almost entirely granulate, or granulate only at the sides. In one undercolored individual, possibly teneral, the scutellum is entirely pale, and the lateral pale border of the elytra appears to cover all of the explanate margin, although a vague demarcation in the usual place is discernible. Length 8.5–11.5 mm.

DISTRIBUTION. ARKANSAS. *Fayetteville,* Washington County: VI–14–53, L. H. Rolston: holotype, 8 paratypes (CAS); 4 paratypes (U.Ark); 1 paratype (Frost); 1 paratype (OSU). *Mt. Sequoyah,* Washington County: M. W. Sanderson: 1 paratype, VII–17–38 (CAS); 1 paratype, VII–20–38 (CAS); 1 paratype, VI–20–38 (CAS); 1 paratype, VII–14–38 (INHS); 1 male, VII–8–40 (INHS). OKLAHOMA. Locust Grove: 1 paratype, VI–29–53, D. J. & J. N. Knull (OSU). *Ellerville:* 1 paratype, VI–20–37, Standish-Kaiser (CAS).

This species is unique in our fauna in having the lateral pale border of the elytra confined to the outer edge of the explanate margin. The author is greatly indebted to Dr. L. H. Rolston for the good series from which the holotype was selected.

(15) **Photinus frosti** Green, new species

HOLOTYPE. MALE; Levy County, Florida, IV–3–54, H. V. Weems, Jr. In collection of California Academy of Sciences.

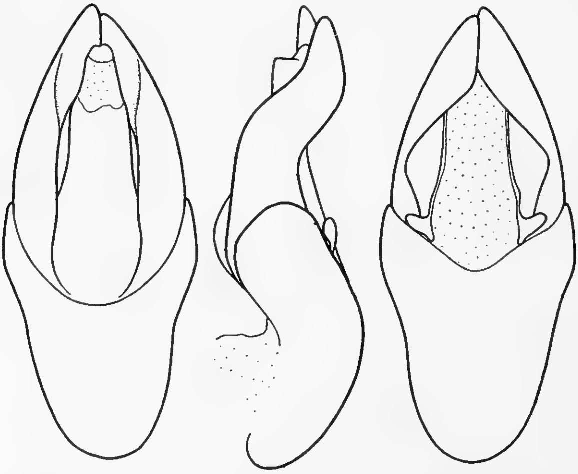


Fig. 14. *Photinus frosti* Green, new species. Holotype; Levy County, Florida, IV–3–54, H. V. Weems, Jr. (CAS). Male genitalia: dorsal, lateral, and ventral views, arranged in that order from left to right.

Form similar to *P. consanguineus.* Pronotum with subtriangular central dark spot not quite attaining base and not entering anterior coarsely punctate area, widest in front where it is about one-third as wide as convex disk, narrowing posteriorly. Scutellum piceous black, apical half fulvous, mesonotal areas clear pale fulvous. Elytra piceous black, sutural bead fulvous, lateral pale border wider, scarcely exceeding width of explanate margin medially, narrowly continuous around apex; epipleurae fuscous basally. Ventral segments 2 to 5 black, 6 to 9 pale; pygidium dark piceous.

Eyes large, separated medially above by less than diameter of eye. Disk of pronotum with deep median longitudinal channel, surface more strongly and closely punctate than usual, punctures coarser on dark area, separated by one to three times their diameters, smaller and less regularly spaced than in *P. punctulatus.* Epipleurae very narrow except at base, attaining abdomen. Ventral segments 6 and 7 large, entirely luminous. Aedeagus as in figure 14, pale fulvous, dorsal inner margins of lateral lobes feebly infuscate subdistally. Length 9 mm.

FEMALE. Unknown, probably brachypterous.

VARIATIONS. The single paratype differs from the holotype in the slightly paler elytra with the fulvous borders continuing rather broadly around the apices. Length 7.5 mm.

DISTRIBUTION. Florida. *Levy County:* holotype. Louisiana. *Ida:* 1 paratype, VI–6–51, Price, Beamers, & Weed (U.Kans).

This species is named in honor of Mr. C. A. Frost, from whom the holotype was received, having been sent to him for identification by Dr. H. V. Weems, Jr., of the Florida State Plant Board. The author is greatly indebted to Dr. Weems for permission to retain the holotype on permanent deposit in the collection of the California Academy of Sciences. The comparatively coarse punctation of the pronotal disk distinguishes *P. frosti* from all related species except *P. punctulatus.* In the latter species the pronotal punctation is still coarser, closer, and more regularly spaced; and the pygidium is abruptly pale, contrasting sharply with the preceding dark tergites. In *P. frosti* the pygidium and preceding tergites are concolorous dark piceous.

(16) **Photinus umbratus** LeConte

Photinus umbratus LeConte, 1878, Amer. Philos. Soc., Proc., 17:407.

MALE. Form similar to *P. consanguineus.* Pronotum with median dark spot not attaining base or apex, narrowing posteriorly, abruptly and diffusely expanding in anterior coarsely punctate area. Scutellum and mesonotal areas fulvous. Elytra piceous black, sutural bead and narrowly explanate lateral margin fulvous, pale color distinctly limited internally, narrowly continuous around apex. Ventral segments 2 to 5 black, 6 to 9 pale; pygidium dark piceous.

Eyes large, separated medially above by less than diameter of eye. Disk of pronotum minutely and sparsely punctulate, punctures more or less subgranulate, at least at sides; median longitudinal line distinctly impressed. Epipleurae very narrow and subobsolete except at base. Ventral segments 6 and 7 large, entirely luminous. Aedeagus pale flavate, similar in structure to figure 15, median lobe broader.

FEMALE. Alate, similar to male. Eyes smaller, separated by more than diameter of eye. Ventral surface of abdomen dark piceous, slightly paler apically, segment 6 pale and luminous in median third or more of width.

LENGTH. Both sexes, 6.5–8 mm.

DISTRIBUTION. NORTH CAROLINA. *Dunn:* V–31 (NCDA). SOUTH CAROLINA. *Charleston:* II–11–32, on okra from Cuba (USNM). GEORGIA. *Thomasville:* VI–14, P. W. Fattig (Em.U). *Okefenokee Swamp:* VII–25–39. P. B. Lawson (U.Kans). FLORIDA. *Baldwin:* VI–1 (MCZ – LeConte type); VI–10, Hubbard & Schwarz (USNM). *Cocos Beach:* VII (CU). *Deland:* VII–8–39, A. T. Hardy (U.Kans). *Tampa:* X–4 (MCZ – LeConte col.). *Enterprise:* (AMNH). *Lake Placid:* III–6 to V–8, J. G. Needham (CU). *Leesburg:* Lake County, VIII–24–38, Hubbell & Friauf (CAS). *Plant City:* VIII–15–30, J. O. Nottingham (U.Kans). *Sebastian:* VII–27–48, H. W. Crowder (U.Kans). *Winter Park:* IV–4, A. B. Klotz (AMNH). *Jupiter:* V–19–48, M. Cazier (AMNH). *Punta Gorda:* IV–10–40, H. Ramstadt (CNHM). ALABAMA. *Cowarts:* VIII–1 (AMNH). MISSISSIPPI. *Hattiesburg:* VII–30 (AMNH). *Lucedale:* V–14–30, H. Dietrich (CU & CAS). *Wareland:* V–25–92, H. Soltau (USNM). LOUISIANA. *Pearl River:* VI–4–93, H. Soltau (USNM).

This species is the only member of the *P. punctulatus* group in which the female is known to be alate and similar to the male. In color pattern it closely resembles *P. collustrans,* differing only in pronotal maculation—the dark area median in *P. umbratus* and anterior in *P. collustrans.* Sometimes, although rarely, the pronotal dark area of *P. collustrans* may extend posteriorly along the median channel in imitation of *P. umbratus,* but these atypical individuals may as a rule be readily identified by their more elongate form and shorter antennae.

(17) **Photinus collustrans** LeConte

Photinus collustrans LeConte, 1878, Amer. Philos. Soc., Proc., 17:407.

MALE. Form elongate, as shown in figure 19. Disk of pronotum rufous or fulvous, anterior coarsely punctate area dark piceous, more or less diffusely so in front, dark color sometimes extending posteriorly a short distance along median channel. Scutellum and mesonotal areas fulvous. Elytra piceous black, sutural bead and narrowly explanate lateral margin fulvous. pale color distinctly limited internally, narrowly continuous around apex. Ventral segments 2 to 5 piceous black, 6 to 9 pale; pygidium black.

Eyes large, separated medially above by less than diameter of eye. Pronotum only slightly wider than long, usually broadly rounded in front, lateral margins subparallel; disk with deeply impressed median longitudinal channel extending to base, surface finely and sparsely punctulate, punctures more or less subgranulate laterally. Elytra each tapering posteriorly, lateral and sutural margins feebly converging from humerus to near apex; epipleurae subobsolete except at base. Ventral segments 6 and 7 large, entirely luminous; apex of pygidium bisinuately subtruncate. Aedeagus pale fulvous, similar in structure to figure 15.

FEMALE. Dissimilar, elongate, brachypterous, of soft larval texture. Pronotum, scutellum, and elytra colored as in male; adbomen pale fulvous throughout, terminal tergites slightly darker, ventral segment 6 whitish and luminous in median third or more of width. Eyes small, separated by slightly more than diameter of eye. Elytra slightly longer than pronotum, attaining middle of first abdominal tergite, strongly dehiscent from scutellum. Three examples collected at Gainesville, Florida, V–25 & VI–5–47, Jack Stevens (CAS).

LENGTH. Both sexes, 5.25–9.5 mm.

DISTRIBUTION. Georgia. *Okefenokee Swamp:* VII–30–48, L. D. Beamer (U. Kans); Billy's Island, VI (CU). *Decatur County:* Spring Creek, VI–7 to 23 (CU). Florida. *Enterprise:* V–20 (MCZ – LeConte type); IV–23 (CAS); IV–24 (OSU). *Fort Myers:* IV–23 (AMNH); VIII–11–30, L. D. Tuthill (U.Kans). *Lake Placid:* V–8 (CU). *Lakeland:* XI–10 (AMNH). *Kissimmee:* (AMNH). *Eau Gallie:* VIII–8 (U.Mich). *Stuart:* V–13 (U.Mich). *Dunellen:* VIII–3 (U.Mich). *Fort Lauderdale:* IV–6–47, J. W. Green (CAS). *Gainesville:* V to VIII, J. Stevens (CAS). *Osceola County:* IV–4–50 (U.Fla). *Ocala N. F.:* V–17–39, D. J. & J. N. Knull (OSU). *Arcadia,* De Soto County: III–30–54, H. E. Evans (CU). *Zolfo Springs,* Hardee County: IV–2–46, G. Rueckert (CNHM). *Okeechobee:* VII–9 (UO).

(18) **Photinus stellaris** Fall

Photinus stellaris Fall, 1927, Brooklyn Ent. Soc., Bull., 22:210.

MALE. Form elongate, as in *P. collustrans.* Pronotum without central dark spot, convex disk rufous, coarsely punctate borders flavate, the anterior rarely somewhat dusky. Scutellum and mesonotal areas fulvous. Elytra entirely black. Ventral segments 2 to 5 dark piceous, 6 to 9 pale; pygidium black.

Eyes large, separated medially above by less than diameter of eye. Pronotum only slightly wider than long, usually broadly rounded in front, lateral margins subparallel; disk with deeply impressed median longitudinal channel, surface irregularly punctulate, punctures fine and sparse medio-anteriorly, coarser and denser at sides and base. Elytra each tapering posteriorly, lateral and sutural margins feebly converging from humerus to near apex; epipleurae subobsolete except at base. Ventral segments 6 and 7 large, entirely luminous; apex of pygidium bisinuately subtruncate. Aedeagus as in figure 15, pale fulvous.

FEMALE. Dissimilar, elongate, brachypterous, of soft larval texture. Pronotum, scutellum, and elytra colored as in male; abdomen pale flavate throughout, terminal tergites somewhat darker, ventral segment 6 whitish and luminous in median third or more of width; legs pale. Eyes small, separated by slightly more than diameter of eye. Antennae short and stout, subcylindrical, segment 3 about one-third longer than 2, 2 to 10 each nearly as wide as long. Elytra slightly shorter than pronotum, attaining first abdominal tergite, strongly dehiscent from near scutellum. Three examples collected 7 miles S.E. of Fort Davis, Texas, V–15–28, Barber, Lattimer, & Russell (USNM).

LENGTH. Both sexes, 6.5–9 mm.

DISTRIBUTION. TEXAS. *Alpine:* VI–15 to 30, O. C. Poling (CAS); V–1 to VIII–1 (CU). *Marfa:* VII–12–11, J. W. Green (CAS). *Fort Davis:* V–15 to 25, IX–15 to 30, X–15 (CU); Limpia Canyon, VII–15 (AMNH);

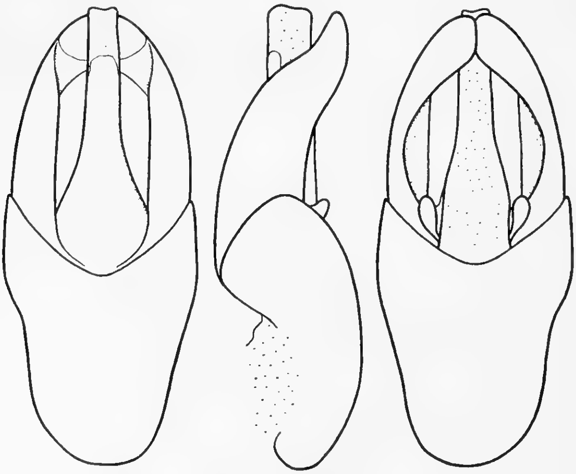


Fig. 15. *Photinus stellaris* Fall. 7 mi. SE Fort Davis, Texas, VI–22–48, H. S. Barber (USNM). Male genitalia: dorsal, lateral, and ventral views, arranged in that order from left to right.

VI–12–48, H. S. Barber (USNM); 7 mi. S.E., VI–12–48, Barber, Lattimer, & Russell (USNM); V–15–28, Chamberlain (CAS). *Davis Mountains:* VI–2 (OSU). *Brewster County:* VI–VII (CU, CAS). *Uvalde County:* V–3 & 11 (OSU). *Uvalde:* IV–29–15, D. C. Parman (USNM). *Val Verde County:* V–13 (OSU). *Comal County:* V–19 (OSU). *Sonora:* IV, V–3 & 9 (A & M.Tex). *Del Rio:* IV–13–49, Michener & Beamer (U.Kans). *San Juan:* VI–28–38, L. W. Hepner (U.Kans). *Rio Frio:* V–11–10, F. C. Pratt (USNM). *Mills:* (AMNH).

(19) **Photinus granulatus** Fall

Photinus granulatus Fall, 1927, Brooklyn Ent. Soc., Bull., 22:209.

MALE. Form similar to *P. collustrans*, elytra less elongate, usually not reaching abdominal apex. Pronotum with central subtriangular dark spot, widest in front, not attaining base or apex. Scutellum and mesonotal areas pale fulvous. Elytra piceous black or brown, sutural bead flavate, lateral pale border somewhat wider medially than the very narrow explanate margin, narrowly continuous around apex. Ventral segments 2 to 5 dark piceous, 6 to 9 pale; pygidium dark.

Eyes large, separated medially above by less than diameter of eye. Antennae short, subcylindric, feebly compressed distally. Pronotum usually broadly rounded in front, lateral margins subparallel; disk with median longitudinal channel shallow, often poorly defined and more or less obsolete anteriorly, surface rather coarsely and irregularly granulate-punctate. Elytra each tapering posteriorly, lateral and sutural margins feebly converging from humerus to near apex; epipleurae obsolete except at base. Ventral segments 6 and 7 large, entirely luminous; apex of pygidium broadly rounded or subtruncate. Aedeagus pale fulvous, similar in structure to figure 15, median lobe broader, ventro-basal processes rudimentary.

FEMALE. Dissimilar, elongate, brachypterous, apparently apterous. Pale fulvous above and beneath, pronotum with convex disk nubilously fuscous anteriorly, elytra slightly darker, margins and base pale. Antennae fuscous, short and stout, second segment subequal in length to third. Eyes small, separated by slightly more than diameter of eye. Pronotum granulate as in male. Elytra very small, about three-fourths as long as pronotum, attaining basal fifth of first abdominal tergite, strongly dehiscent from scutellum. Lateral extension of metacoxa bent obliquely forward in line with oblique posterior margin of metepimeron, ventral segment 1 plainly visible at sides, subequal in length to ventral segment 2. Ventral segment 6 apparently luminous in median third of width. One example, collected on alfalfa at Manhattan, Kansas, VII–2–24, I. Kenberry (KSC).

LENGTH. Both sexes, 5.5–8 mm.

DISTRIBUTION. KANSAS. *Riley County,* Popenoe: (KSC & CAS). *Lawrence,* VII–1–53, P. J. Spangler (U.Mo); VI–27–53, P. J. Spangler (CAS); VII–13–50, H. S. Fitch (U.Cal). *Douglas County:* VI–9 to 15–1919, W. E. Hoffman (CAS & U.Kans). *Emporia:* VI–11 (McClay). *Madison:* M. C. Van Duzee (CAS). *Wellington:* VII–1–50, R. P. Allen (CAS). OKLAHOMA. *Sapulpa:* V–25, F. C. Bishop, J. D. Mitchell (USNM). TEXAS. *College Station:* VI & VII–1932, J. C. Gaines (A & M.Tex). *Mexia:* VII–27–37 (A & M.Tex).

This is one of the most easily recognized Nearctic species of *Photinus* because of the strongly granulate disk of the pronotum. The terminal antennal segment of the female appears from some viewpoints to have a minute globular apical constriction resembling the terminal appendix of the tribe *Lampyrini.* The female of *Lampyris noctiluca,* and probably of other species of the genus, have abdominal ventral segment 1 exposed at the sides in the same manner as described for *Photinus granulatus.*

(20) **Photinus dimissus** LeConte

Photinus dimissus LeConte, 1881, Amer. Ent. Soc., Trans., 9:35.

MALE. Form similar to *P. collustrans,* elytra less elongate, usually not reaching abdominal apex. Pronotum with central subtriangular dark spot, widest in front, not attaining base or apex. Scutellum and mesonotal areas pale fulvous, varying to dusky. Elytra piceous brown, sutural bead flavate, lateral pale border somewhat wider than the very narrow explanate margin, narrowly continuous around apex. Ventral segments 2 to 5 piceous brown, 6 to 9 pale; pygidium dark.

Eyes large, separated medially above by less than diameter of eye. Antennae compressed. Pronotum broadly rounded in front, lateral margins subparallel or feebly converging posteriorly; disk with median longitudinal channel deeply impressed, surface irregularly punctate, punctures sometimes comparatively coarse. Elytra each tapering posteriorly, lateral and sutural margins feebly converging from humerus nearly to apex. Epipleurae obsolete except at base. Ventral segments 6 and 7 large, entirely luminous; apex of pygidium broadly rounded or subtruncate. Aedeagus pale fuscous, similar in structure to figure 15, median lobe broader.

FEMALE. Dissimilar, brachypterous. Pale fulvous above and beneath, pronotal spot and elytra, except margins, somewhat darker. Antennae shorter, second segment more elongate, slightly shorter than third. Eyes small, separated by slightly more than diameter of eye. Elytra small, nearly as long as pronotum, attaining basal third of first abdominal tergite, strongly dehiscent from scutellum. Metacoxae and side pieces of metasternum normal, ventral segment 1 not visible. Ventral segment 6 probably luminous as usual, but this is not apparent. One example collected at Fedor, Lee County, Texas, V, H. Klages (CM).

LENGTH. Both sexes, 5–7 mm.

DISTRIBUTION. Texas. *Uvalde:* VIII–21–14, D. C. Parman (USNM). *Victoria:* IX–10–15, D. C. Mitchell (USNM). *Smetara:* VIII–31–49, L. S. Dillon (CAS). *Denton County:* V–27–34, J. H. Robinson (CAS). *Hockley:* (AMNH). *Florence:* V–30–41, E. L. Thackrey (CAS). *Fedor:* (CU & CM); VI–15–99 (U.Mo); V–20–19, Rev. Brinkman (U.Mo). *Dallas:* VI–15 (Frost); VI–18–06, W. D. Pierce (USNM). *Houston:* V–15–47, (USNM); VI–28–52, H. E. Cott (U.Cal). *Kerrville:* V–30–06, F. C. Pratt (USNM). *Columbus:* V–25, E. A. Schwarz (USNM). *Victoria County:* V–15–11, J. D. Mitchell (USNM). *College Station:* IV–20 to VI–19 (A & M.Tex). *Duval County:* Rialitos, VI–29 (U.Mich). *Gillespie County:* VI-7 to 29 (OSU). *Harris County:* III (Frost). *Temple:* VIII–22–41, H. Dybas (CAS). Oklahoma. *Ada:* VII–16–37, Standish-Kaiser (CAS). *Idabel:* VI–30–37, Standish-Kaiser (CAS). *Lebanon:* VII–2–37, Standish-Kaiser (CAS). *Grant:* VII–1–37, Standish-Kaiser (CAS). *Oswalt:* VII–3–37, Standish-Kaiser (CAS). *Comanche County:* Wichita National Forest, VI–11 (U.Mich).

(21) **Photinus knulli** Green, new species

HOLOTYPE. MALE; Nogales, Arizona, VIII–4–1953, D. J. & J. N. Knull. In collection of Ohio State University.

Form similar to *P. consanguineus.* Pronotum with irregular median

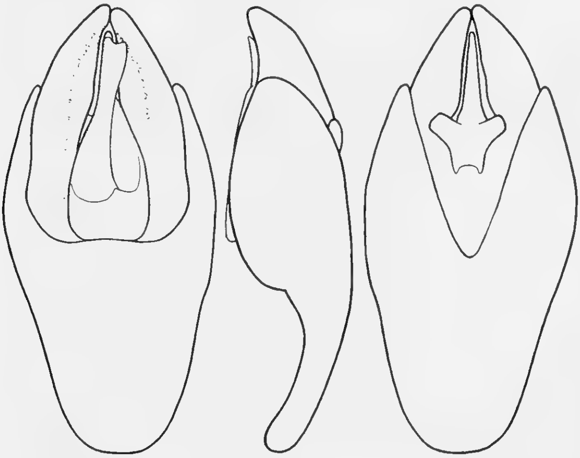


Fig. 16. *Photinus knulli* Green, new species. Holotype; Nogales, Arizona, VIII–4–53, D. J. and J. N. Knull (OSU). Male genitalia: dorsal, lateral, and ventral views, arranged in that order from left to right.

dark vitta attaining base, diffusing in anterior coarsely punctate area without reaching apex, vitta widest in front, nearly one-third as wide as convex disk, narrowing posteriorly to near base, then expanding; reflexed lateral margin vaguely dusky medially. Scutellum pale piceous, mesonotal areas darker. Elytra piceous black, sutural bead flavate, lateral pale border wider, not exceeding width of explanate margin, narrowly continuous around apex. Ventral segments 2 to 5 black, 6 to 8 pale, 9 dusky; pygidium black.

Eyes large, separated medially above by less than diameter of eye. Disk of pronotum minutely and sparsely punctulate, without median impressed line. Epipleurae narrow except at base, attaining abdomen. Ventral segments 6 and 7 large, entirely luminous, apical margin of 8 shallowly arcuately emarginate; apex of pygidium broadly truncate. Aedeagus as in figure 16, flavate, lateral lobes strongly sclerotized, dark brown beneath and at tips. Length 8 mm.

FEMALE. Alate, similar to male. Eyes smaller, separated by more than diameter of eye. Pronotal vitta of nearly uniform width throughout, about one-third as wide as convex disk, reflexed lateral margin not dusky medially. Scutellum and mesonotal areas dark piceous. Ventral surface of abdomen dark piceous, segment 6 pale and luminous in median third or more of width; apex of pygidium narrowly rounded. Length 7.5 mm.

DISTRIBUTION. ARIZONA. *Nogales:* holotype; 1 female, VIII–2–53, D. J. & J. N. Knull (OSU).

This species differs from all other members of the *P. consanguineus* group by its distinctive male genitalia. It is represented at present only by the male and female above described. Dr. Knull reports that both specimens were taken at light, that no others were seen flying, and that no flashing was noted in either sex. The species is named in honor of Doctor and Mrs. Knull.

(22) **Photinus indictus** (LeConte)

Pyropyga indicta LeConte, 1881, Amer. Ent. Soc., Trans., 9:32.
Photinus ablucens Fall, 1927, Brooklyn Ent. Soc. Bull., 22:209 (new synonymy).

MALE. Form similar to *P. consanguineus.* Pronotum with median dark vitta attaining base and sometimes nearly apex, one-third to two-fifths as wide as convex disk, slightly narrowing posteriorly, sometimes abruptly expanding near base. Scutellum and mesonotal areas dark piceous. Elytra piceous black, sutural bead flavate usually to scutellum, lateral pale border wider, slightly exceeding width of explanate margin, continuous around apex, pale borders well defined. Ventral segments dark piceous, segments 6 to 8 often irregularly paler; pygidium with sides and apex broadly pale.

Eyes small, separated medially above by more than diameter of eye. Disk of pronotum finely and sparsely punctulate, median longitudinal line not impressed. Epipleurae narrow except at base. Ventral segments 6 and 7 each subequal in length to segment 5, light organs lacking; pygidium broadly truncate. Aedeagus similar to *P. consanguineus.*

FEMALE. Alate, similar to male. Eyes slightly smaller. Ventral segments uniformly piceous black or brownish, varying with distal segments irregularly more or less pale, light organs lacking; pygidium narrowly rounded at apex.

LENGTH. Both sexes, 6.5–8 mm.

DISTRIBUTION. Ohio. *Newark:* VI–7–99 (OSU). *Ira,* Summit County: VII–15–20, J. S. Hine (OSU). *Delaware County:* VI–2 (OSU). *Amherst:* VII (A & M.Tex). *Toledo:* VI–20 (U.Mich) *Frankfort,* Ross County: VIII–10 (OSM). *Pleasant Run,* Lancaster County: VI–3 (OSM). *Marysville,* Union County: VII–4 (OSM). Michigan. Mt. Clemens: VI–15 to VII–10–34, B. Malkin (CAS). *Midland County:* VI–12 to VII–11–38 (CAS). *Lake County:* VII–20 (Dreisbach). *Lapeer County:* VII–19 (Dreisbach). *Crawford County:* VII–1–39, R. R. Dreisbach (CAS). *Clare County:* VII–23–39, R. R. Dreisbach (CAS). *Wexford County:* VII–3 (Dreisbach). Indiana. *Valparaiso:* VIII–1 (INHS). *Mineral Springs:* VII–4–10, A. B. Wolcott (CNHM). *Hessville:* VII–2–11, W. J. Gerhard (CNHM). *Cromwell:* VI–21–32, H. E. Brown. Illinois. *Lake Forest:* VI–5 & 13 (CU). *Champaign:* VI–23 (INHS). *Evanston:* VI–23–33, J. H. Robinson (CAS). *Algonquin:* V–21 to VII–17 (INHS). *Pulaski:* V–28 (INHS). *Princeton:* VII–2 (INHS). Wisconsin. *Delavan:* Walworth County, VI–18–40, H. Dybas (CNHM). *Waupaca:* VI–6 & 9–1920, L. D. Geniner (USNM). *West Bend:* Washington County, VI–23–06, G. W. Bock (U.Mo). Minnesota. No definite locality (USNM). Tennessee. *Camden:* VIII–9–53, R. X. Schick (UCLA). Georgia. *Atlanta:* VII–2, P. W. Fattig (Em.U); VI–16–47, P. W. Fattig (USNM). Alabama. *Florence:* Wilson Dam, VIII–11–53, R. X. Schick (UCLA). Louisiana. *Opelousas:* IV–17 (OSU). *Baton Rouge:* V–16–34, F. E. Lyman (U.Kans). *Mandeville:* VI–17–17, R. C. Shannon (CU). Texas. *Dayton:* VI–30–18, E. L. Diven (USNM). *Harrison County:* III–25, V–18 (OSU). *Lufkin,* Angelina County: V–9–52, Cazier *et al.* (AMNH). Arkansas. *Hope:* V–28, VIII–5 (CU & Frost); V–6 (CAS). *Washington County:* VII–27 (INHS). Missouri. *Sikeston:* V–12–30, P. H. Johnson (U.Mo). *Columbia:* VII–3–46, W. S. Craig (U.Mo). *Cape Girardeau:* VIII–11–49, W. R. Enns (U.Mo). *St. Louis:* VI–1–1919 (U.Mo). Kansas. *Douglas County:* VII–5–53, P. J. Spangler (U.Mo); F. H. Snow (U.Kans). Nebraska. No definite locality (USNM). South Dakota. *Clear Lake:* VI–27 (SDSC). *Waubay:* VI–22 (SDSC). *Sioux River, Volga:* VI–22 (SDSC). *White:* VII–26 (SDSC). Ontario. *Toronto:* (CAS).

The new synonymy herein proposed was established by an examination of the type series of *Photinus ablucens* in the Fall collection at the Museum of Comparative Zoology. In describing *Pyropyga indicta* LeConte mentioned an example taken by Bolter at Lake Tahoe, California. This is without doubt another instance of mislabeling of the Bolter material.

(23) **Photinus lineellus** LeConte

Photinus lineellus LeConte, 1851, Acad. Nat. Sci. Philadelphia, Proc., (2), 5:335.

MALE. Form narrowly elongate. Pronotum with broad median dark vitta narrowing posteriorly, usually attaining base but not apex. Scutellum and mesonotal areas black. Elytra black, pale sutural and lateral borders uniformly narrow and well defined throughout, continuous around apex. Ventral segments 2 to 5 black, 6 to 8 pale fulvous, 9 dark; pygidium abruptly pale flavate, preceding tergites black.

Eyes large, separated medially above by less than diameter of eye. Pronotum nearly as long as wide, lateral margins subparallel; disk finely and sparsely punctulate, usually with distinctly impressed median longitudinal line. Epipleurae obsolete except at base. Ventral segments 6 and 7 large, entirely luminous; pygidium broadly truncate at apex. Aedeagus similar to *P. consanguineus.*

FEMALE. Alate, similar to male, form broader. Eyes smaller, separated by more than diameter of eye. Ventral surface of abdomen dark piceous, slightly paler apically, segment 6 pale and luminous in median third or more of width, sometimes pale each side, 7 sometimes pale basomedially; pygidium dark, apex rounded or narrowly truncate.

LENGTH. Both sexes, 4.5–6.5 mm.

DISTRIBUTION. MISSISSIPPI. *Lucedale:* IV–22–1929, H. Dietrich (CU). ALABAMA. *Chickasaw:* IV–6 (CU). FLORIDA. *Paradise Key:* Dade County, III–27–54, C. M. Yoshimoto (CU). *Dunedin:* IV–8–26, W. S. Blatchley (CU). *Rockledge:* X–16–54, A. Cruikshank (CAS). *Enterprise:* V–16, Hubbard & Schwarz (USNM). *Lake Placid:* Archbold Biological Station, III–12, V–14 (CU); VII–13–48, E. L. Todd (U.Kans); Archbold Biological Station, I–27 (AMNH). *Homestead:* VII–19–39, P. B. Lawson (U.Kans). *Bradentown:* VIII–6–38, W. Benedict (U.Kans). *Sanford:* VII–28–48, B. T. McDermott (U.Kans). *Stuart:* VI–25–51, O. Bryant (CAS). *Tampa:* IV–10–43, B. Malkin (CAS). *Titusville:* XI–8 (AMNH). *Ormond:* (AMNH). *La Belle:* IV–27 (AMNH) *Everglade:* IV–9 (AMNH). *Capron:* IV–20 (INHS). *New Smyrna:* VI–2, (OSU). *Fort Lauderdale:* V-25 (U. Mich). *Satsuma:* VII–30 (U.Mich). *Orange County:* IX–27–1929, W. M. Loe (USNM). *Lakeland:* V–6, XI–9 (AMNH). *Royal Palm Park:* VII–20–48, E. L. Todd (U.Kans).

This species may be easily recognized by its small size and narrow elongate form, and by the pale pygidium of the male contrasting sharply with the preceding dark tergites. The abruptly pale pygidium is found elsewhere in the Nearctic *Photinus* only in *P. punctulatus,* a larger species with comparatively coarsely punctate pronotum. A male specimen in the National Museum collection, labeled "Sand Hills, Neb., July, L. Bruner," agrees closely with *P. lineellus* in every respect, including the characteristic pale pygidium, except in having the pronotum immaculate. It bears determination label "demissus, 1911, Ern. Olivier." It seems probable that this specimen is a mislabeled example of *P. lineellus.*

(24) **Photinus ignitus Fall**

Photinus ignitus Fall, 1927, Brooklyn Ent. Soc., Bull., 22:208.

MALE. Form distinctly more elongate than *P. consanguineus,* pronotum narrower, elytra longer. Pronotum with median brownish vitta, rarely darker, attaining base but not apex, sometimes much reduced in size or lacking altogether. Scutellum with tip pale. Elytra dilute brownish piceous, sutural bead flavate, lateral pale border confined nearly to explanate margin. Ventral surface and aedeagus as in *P. consanguineus.*

FEMALE. Form shorter and broader, similar to *P. consanguineus.*

LENGTH. Both sexes, 7–11 mm.

DISTRIBUTION. MAINE, *Monmouth:* VII–16 (Frost). *Eastbrook:* VII–15 (Frost). *Paris:* VII–12 & 19 (Frost). *York Harbor:* VIII–7–39, Henry Field (CNHM). *Rockland:* VII (INHS). NEW HAMPSHIRE. *Durham:* VII–19 (INHS). *Hampton:* VI–24 to VII–31 (EL.Aug). MASSACHUSETTS. *Framingham:* VII–4 & 18 (Frost). *Sherborn:* VI–23 (Frost). *Natick:* VII–15 (Frost). *Southboro:* VI–29 (Frost); VI–13 (CU). *Ware:* VI–26 (Frost). *Marshfield:* VII–5 (INHS). RHODE ISLAND. *Narragansett:* VII–3 (OSU). CONNECTICUT. *Litchfield:* VI–28 (AMNH). *Cornwall:* VI–20 (CU). *Mansfield:* VI–28, VII–7, J. A. Manter (FSPB). *Storrs:* VI–28–20, J. A. Manter (FSPB). NEW YORK. *Ithaca:* VI–4 to VIII–4 (CU). *Elmira:* VI–17 & 21 (CU). *Armonk:* VII–21 (CU). *Minetto:* VI–23 (CU). *McLean Bogs:* VI–23 to VII–3 (CU). *New York:* VI–15 (Malkin). *Flatbush,* L. I.: VI–29 (AMNH). *Taughannock:* VI–27 (OSU). *New Rochelle:* VIII–7 to 15 (AMNH). *Bear Mountain:* VI–29–47, B. L. Ladner (U.Cal). *Islip,* L. I.: VII–3–48, J. G. Rozen (U.Cal). PENNSYLVANIA. *Easton:* VI–11 to VII–19, J. W. Green (CAS). *Wind Gap:* VI–20 to VII–26, J. W. Green (CAS). *Pocono Lake:* VI–11, J. W. Green (CAS). *Columbia Crossroads:* VII–14 (UO). *Hummelstown:* VII–15 (OSU). *Rickets,* North Mountain: VII–10, H. W. Wenzel (OSU). NEW JERSEY. *Phillipsburg:* VI–24, J. W. Green (CAS). *New Brunswick:* VII–12 (AMNH). *Ramsey:* VII–9 (AMNH).

Anglesea: VIII–4 (OSU). *Atsion:* VI–27–46, J. W. Green (CAS). Delaware. *Middletown:* VI–24–51 (U.Del). Virginia. No definite locality (INHS). North Carolina. *Gibsonville:* VI–3 (CU). *Raleigh:* VI–11 to VII–13 (NCDA).

The distinguishing characters of the species of *Photinus* are all more or less subject to variation, and specimens of the *ignitus-consanguineus* type will be found that cannot be allocated confidently to one or the other of these species. There is not, however, any doubt concerning the specific validity of *P. ignitus.*

(25) **Photinus consanguineus** LeConte

Photinus consanguineus LeConte, 1851, Acad. Nat. Sci, Philadelphia, Proc., (2), 5:335.
Photinus vittiger LeConte, same as above, page 336.
Photinus zonatus Gemminger, 1870, Col. Hefte, 6:120.

MALE. Form as shown in figure 19. Pronotum with median dark vitta about two-fifths as wide as convex disk, slightly narrowing posteriorly, attaining base but not apex, diffusely entering anterior coarsely punctate area; convex surface each side flavate or rosy. Scutellum and mesonotal areas dark piceous. Elytra piceous black or brown, sutural bead flavate, lateral pale border wider, exceeding width of explanate margin medially, its inner limit usually well defined, rather broadly continuous around apex. Ventral segments 2 to 5 black, 6 and 7 pale, 8 and 9 infuscate; pygidium black.

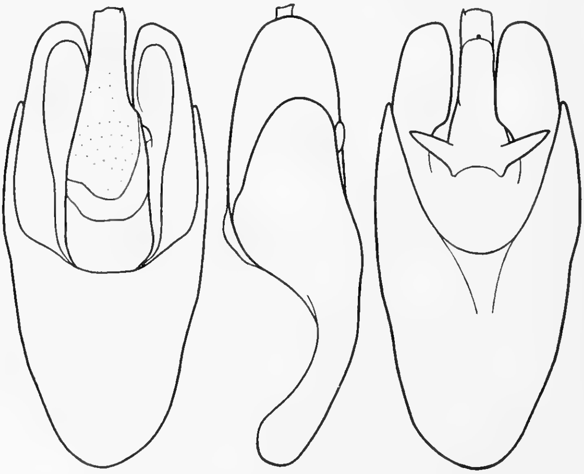


Fig. 17. *Photinus consanguineus* LeConte. Easton, Pennsylvania, VI–24–34, J. W. Green (CAS). Male genitalia: dorsal, lateral, and ventral views, arranged in that order from left to right.

Eyes large, separated medially above by less than diameter of eye. Disk of pronotum finely and moderately closely punctulate, punctures spaced by two to five times their diameters; median longitudinal line usually not impressed. Epipleurae distinct, attaining middle of abdomen. Ventral segments 6 and 7 large, entirely luminous; pygidium broadly truncate. Aedeagus as in figure 17, ventrobasal processes varying to apices truncate.

FEMALE. Alate, similar to male, not differing appreciably in form. Eyes smaller, separated by more than diameter of eye. Ventral segment 6 pale and luminous in median third or more of width, usually pale, or partially so, each side; segments 7 and 8 brownish fuscous, somewhat mottled, varying to nearly black, segment 7 lacking the pale subapical maculation usually occurring in females of the *P. ardens* group; pygidium narrowly rounded at apex.

LENGTH. Both sexes, 7.5–11 mm.

DISTRIBUTION. Massachusetts. *Woods Hole:* VII (AMNH). *Marthas Vineyard:* VII–17–47, F. M. Jones (CAS). Connecticut. *Litchfield:* VII–20 (AMNH). New York. *Bear Mountain:* VI–25 to VIII–6 (AMNH). *New York:* VI–10 to VIII–3 (AMNH & Malkin). *Montauk,* L. I.: VI–30 (CU). *Flatbush,* L. I.: VI–19 to VII–10 (AMNH). *Riverhead,* L. I.: VI–23 (CU). Pennsylvania. *Easton:* VI–24 to VII–19, J. W. Green (CAS). *Wind Gap:* VII–6–46, J. W. Green (CAS). *Pittsburgh:* VI–20–42, C. O. St. John (CAS). New Jersey. *Phillipsburg:* VI–24, J. W. Green (CAS). *Lakehurst:* VII–4 (CAS). *Atlantic City:* (INHS). *Browns Mills:* VI–10 (AMNH). *Alpine,* Bergen County: VI–24 & VII–9–48, J. G. Rozen (U.Cal). Delaware. *Milford:* VI–2–53, H. E. Milliron (U.Del). *Wilmington:* VI–23–48, F. A. McDermott (CAS). Maryland. *Odenton:* VI–15 & 23 (CU). *Plummers Island:* VI–7 (INHS). District of Columbia. *Chevy Chase:* VI–12–30, H. S. Barber (USNM). West Virginia. *Sistersville:* VI–16–30 (CAS). Tennessee. *Great Smoky Mountains National Park:* VI–10 (Dreisbach). *Gatlinburg:* VI–25–28, R. H. Whittaker. North Carolina. *Raleigh:* VI–18 to VII–7 (NCDA). *Southern Pines:* V–13–1918, A. H. Manee (USNM). *Montreat:* VII–9 (INHS). *Maxton:* IX–17 (AMNH). *Black Mountains:* VI–20 to VII–14 (AMNH). South Carolina. *Oconee County:* VI–19–40, O. L. Cartwright (CAS). Georgia. *Roberta:* V–16–41, P. W. Fattig (USNM). *Okefenokee Swamp:* VII–30–34, M. E. Griffith (USNM). *Waycross:* IV–21–38, W. J. Gertsch (CAS). *Atlanta:* V–28, P. W. Fattig (Em.U). *Lakemont:* VI–5, P. W. Fattig (Em.U). Florida. *St. Augustine:* IV–18 (Frost). *Dunedin:* II–25. (CU). *Alachua County:* III–30–54, H. V. Weems, Jr. (FSPB). *Crescent City:* IV–23 (AMNH). *Enterprise:* X–5 (AMNH). Mississippi. *Lucedale:* IV-21 (CU). Ohio. *Scioto County:* VI–10 & 17 (OSU). Indiana. *Beverly Shrs.,* Porter County: VII–2–39, H. Dybas (CNHM). Texas. *Karnack:* V–22 (OSU).

This species forms with *P. ignitus* a complex that cannot at present be satisfactorily resolved. Typical examples of both *P. consanguineus* and *P. ignitus* are easily recognizable by the characters given in couplet 25 of the key. There are, however, no positive characters known by which nonconforming specimens may be definitely placed. The occasional occurrence of such specimens indicates, perhaps, that one of more additional species are involved. The most confusing of these are darkly pigmented individuals, apparently belonging to *P. consanguineus,* but with the lateral pale border of the elytra narrow and confined to the explanate margin. A number of undersized examples, some as small as 6 mm. in length, have been noted from the South Atlantic States. It is quite likely that among these a valid species might be segregated. Two specimens in the Chicago Natural History Museum collection, from Illinois and Indiana, closely resemble *P. ardens* in appearance, having the form elongate, the pronotum with obscure lateral maculation, and the elytra with very narrow pale borders.

(26) **Photinus consimilis** Green, new species

HOLOTYPE. MALE; Roaring River State Park, Missouri, VI–15–54, J. W. Green. In collection of California Academy of Sciences.

Form similar to *P. pyralis,* less elongate. Pronotum with well defined median dark vitta attaining base, terminating diffusely at anterior coarsely punctate area, about two-fifths as wide as convex disk, slightly broader in front; convex surface each side fulvous, without trace of obscure maculation. Scutellum and mesonotal areas dark piceous. Elytra dark piceous, sutural

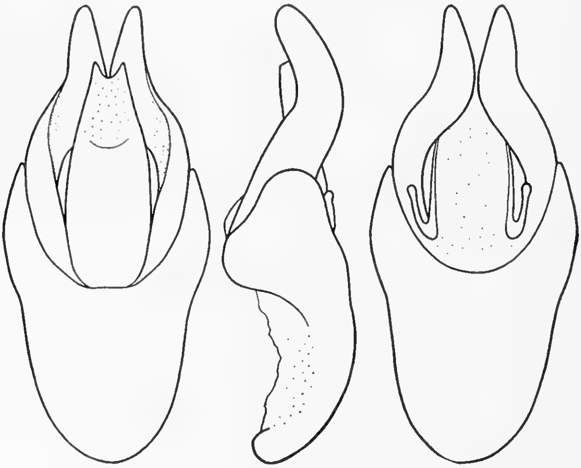


Fig. 18. *Photinus consimilis* Green, new species. Paratype; Hope, Arkansas, IX–10–31 (CAS). Male genitalia: dorsal, lateral, and ventral views, arranged in that order from left to right.

bead flavate, lateral pale border wider except at humerus, exceeding width of explanate margin, rather broadly continuous around apex. Ventral segments 2 to 5 piceous black, 6 and 7 pale flavate, 8 dusky, 9 darkly piceous; pygidium dark.

Eyes large, separated medially above by less than diameter of eye. Pronotum longer as compared to *P. ardens,* anterior margin more narrowly rounded at middle, lateral margins arcuate, slightly converging at hind angles; disk finely and moderately closely punctulate, median impressed line lacking. Epipleurae narrow except at base, attaining middle of abdomen. Ventral segments 6 and 7 large, entirely luminous, 8 not emarginate, middle of its apical margin produced in a short subtriangular cusp extending posteriorly and slightly downward; apex of pygidium rather narrowly rounded. Aedeagus as in figure 18. Length 11.25 mm.

FEMALE. Alate, similar to male, not differing in shape. Eyes smaller, separated by more than diameter of eye. Ventral segment 6 pale and luminous in median third or more of width, pale each side except broadly at basal exterior angles, 7 and 8 entirely dark, varying with 7 maculate with pale spots along apical border, these often confluent so that apical half of segment is pale, the pale area sometimes extending to base medially.

VARIATIONS. The color of the elytra varies from dark piceous to a very dilute brown. The pale elytral borders are usually distinct, but in the palest specimens may blend imperceptibly with the central area. In the pale specimens a darker brown streak may extend backward from the humerus, producing a vaguely vittate effect. In the darker specimens the outer oblique costa of the elytra may be narrowly pale throughout. Rarely the lateral pale border of the elytra is narrower, scarcely exceeding the explanate margin in width. The median vitta of the pronotum may not quite attain base, and may extend diffusely into the anterior coarsely punctate area. Ventral segment 8 of the male varies from entirely pale to entirely dark, and its apical cusp may be reduced to a blunt projection. The outline of the pronotum (figure 19) varies considerably, as in all Lampyridae, and does not constitute an infallible diagnostic character. Length 8–15 mm.

DISTRIBUTION. PENNSYLVANIA. *Tannersville:* 1 female, VII–8–47, J. W. Green (CAS). OHIO. *Millersburg:* 1 paratype, VI–18–31, R. P. Thomas (CAS). MICHIGAN. *Livingston County,* George Reserve: 1 paratype, 1 female, VII–1–33, S. Moore (Dreisbach); 1 female, VII–1–33, S. Moore (CAS); 2 paratypes, VII–10–32, A. W. Andrews (Dreisbach); 2 females, VI–12 & 26–32, A. W. Andrews (Dreisbach); 1 paratype, VII–16–32 (CAS). *Southfield,* Oakland County: 1 paratype, VII–4–31, S. Moore (Dreisbach). *Port Huron:* 1 paratype, VI, Hubbard & Schwarz (USNM). *Pentwater:* 1 paratype, VII–35, H. Dybas (CNHM). No definite locality: 1 paratype, E. Chope (CNHM). INDIANA. *Tremont:* 1 female, VI–26–43, A. K. Wyatt

(CNHM). *Mineral Springs:* 1 female, VII–3–11, F. Psota (CNHM). ILLINOIS. *Chicago:* 1 paratype, VI–28–06, W. J. Gerhard (CNHM); 1 paratype, VI–30–96, J. E. McDade (USNM). *Putnam County:* 1 paratype, VI–17–32, M. C. Glenn (CAS). *Oakwood:* 1 paratype, V–30-32, Coll. Frison (INHS). *Kampville:* 1 paratype, VI–25–31, Frison, et al. (INHS). NEW JERSEY. *Orange:* 1 paratype, VI–20 (USNM). MARYLAND. *Lanham:* 21 paratypes, 1 female, VII–7 & 14–26, H. S. Barber (USNM); 4 paratypes, same data (CAS); 1 paratype, VIII–30–26, H. S. Barber (USNM). *Breton Bay:* 2 paratypes, VII–12–24, H. S. Barber (USNM). *Hills Bridge,* Patuxent River: 2 paratypes, VI–26–24, H. S. Barber (USNM). *Plummers Island:* 1 female, VII–17–24, H. S. Barber (USNM). DISTRICT OF COLUMBIA. Washington: 4 paratypes, 1 female, Shaw Lily Ponds, V–22 & 31–1929, VII–8–1926, H. S. Barber (USNM); 38 paratypes, M Street Marsh, VII–17 & 18–1927, H. S. Barber (USNM). *North River,* 22 mi. ENE. of Washington, 4 paratypes, VI–12–28, H. S. Barber & P. G. Russell (USNM). VIRGINIA. Mouth of *Difficult Run:* 1 female, VI–18–30, H. S. Barber (USNM). NORTH CAROLINA. *Black Mountains:* 1 female, VII–7–12, Beutenmuller (CAS). SOUTH CAROLINA. *Loris:* 1 paratype, V–20–40, B. M. Heniford (CAS). GEORGIA. *Cartersville:* 1 female, VI–14–40, P. W. Fattig (CAS). *Atlanta:* 1 paratype, VI–4–39, P. W. Fattig (CAS). ALABAMA. *Tuscaloosa:* 1 paratype, 1 female, VI–10–52; B. D. Valentine (CAS). *Mobile:* 1 paratype, VI–5–25, C. E. White (INHS). FLORIDA. *Levy County:* 1 paratype, IV–3–54, H. V. Weems, Jr. (FSPB). *Lakeland:* 1 paratype, 1 female, III–16–48, R. F. Hussey (CAS). *Stuart:* 1 paratype, VI–25–51, O. Bryant (CAS). *Lacoochee:* 1 female, VIII–18–30, J. Nottingham (U.Kans). *Sebring:* 1 paratype, VI–20–51, Price, Beamer, Weed (U.Kans); 1 paratype, 1 female, III–7 to 12–1939, F. E. Lutz (AMNH). *Royal Palm Park:* 1 paratype, VII–20–48, E. L. Todd (U.Kans). *Highland Hammock,* near Sebring: 1 paratype, 1 female, III–24, Gertsch (AMNH). *Lake Placid:* 2 paratypes, I–27–43 & II–5–43, M. Cazier (AMNH); 2 females, I–23–43, M. Cazier (AMNH); 1 paratype, V–8–47, and 1 female, III–6–45, Archbold Biological Station, J. G. Needham (CU). *Lake Worth:* 1 paratype, Coll. Mrs. A. T. Slosson (AMNH); 1 paratype (CU). *Everglade:* 1 female, IV–9–1912 (AMNH). *Biscayne Bay:* 1 paratype, Mrs. A. T. Slosson (AMNH). *F. Capron:* 1 male, III–4 (MCZ–LeConte collection); 1 paratype, IV–12, Hubbard & Schwarz (CAS). *Edgewater:* 1 paratype, 1 female, III–12 & 13–1939 (Frost). *Gainesville:* 1 female, IV–25–25, T. H. Hubbell (U.Fla). *Alachua County:* 1 female, VIII–27–54, H. V. Weems, Jr. (Frost). *Belleglade:* 1 paratype, 1 female, VI–2–27, M. D. Leonard (CU). *Enterprise:* 2 paratypes, 2 females, VI–13 to 24, Hubbard & Schwarz (USNM); 1 paratype, same data (CAS). *Paradise Key:* 6 paratypes, 1 male, 4 females, II–19 to III–4–1919, H. S. Barber (USNM). *Brevard County:* 1 paratype, III–18–30, J. Howard (USNM). *Crescent City:* 1 paratype, Hubbard & Schwarz

(USNM). *Dunellen:* 1 paratype, VII–12–30 (USNM). *Sanibel Island:* 1 female, IV–26–27, M. D. Leonard (CU). *Winter Park:* 1 paratype, VI–10–44, H. T. Fernald (Frost); 2 females, VI–5 & 8–45, H. T. Fernald (Frost). Louisiana. *Harahan,* Jefferson Parish: 3 paratypes, 5 females, VII–26 to VIII–24–44, H. Dybas (CNHM). *Crowley:* 1 paratype, VII–29–10, C. E. Hood (USNM). *Gueydan:* 2 paratypes, V–28 & VII–21–1925, E. Kalmbach (USNM). No definite locality: 1 female (U.Mo). Missouri. *Roaring River State Park:* holotype, 6 paratypes, 5 females, VI–15–54, J. W. Green (CAS); 1 paratype, same data (Frost). Arkansas. *Prairie County:* 1 male, VII–1–26, T. E. White (U.Kans) *Hope:* 2 paratypes, 1 female, IX–10–31, coll. Mank (CU); 1 paratype, same data (CAS). Oklahoma. *Eagletown:* 1 paratype, VI–28–37, Standish-Kaiser (CAS). *Sherwood:* 1 paratype, VI–27–37, Standish-Kaiser (CAS). Canada. No definite locality: 1 paratype, coll. J. B. Smith (USNM).

In general appearance this species rather closely resembles *P. consanguineus,* with which it has heretofore usually been confused. In the LeConte collection *P. punctulatus* number 2 and *P. consanguineus* numbers 10 and 11 are examples of *P. consimilis.* The pale form of *P. consimilis* predominates in Florida, and has been noted from Louisiana and Arkansas. Mixed series, of pale and dark individuals, from the same locality precludes any subspecific segregation.

(27) **Photinus carolinus** Green, new species

HOLOTYPE. MALE; Mt. Mitchell, North Carolina, 6711 ft., VI–24–37, Hans L. Stecher. In collection of California Academy of Sciences.

Form similar to *P. consanguineus,* less elongate than *P. ardens.* Pronotum with well defined median dark vitta attaining base, not entering

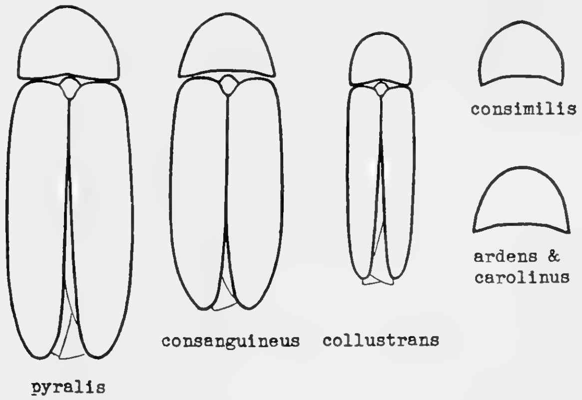


Fig. 19. Body outlines of *Photinus pyralis, P. consanguineus,* and *P. collustrans,* and pronotum outlines of *P. consimilis, P. ardens,* and *P. carolinus.*

coarsely punctate anterior area, of nearly uniform width throughout, almost half as wide as convex disk; pale area each side rosy, not obscured by darker maculation. Scutellum and mesonotal areas dark piceous. Elytra piceous black, sutural bead pale fulvous, lateral pale border scarcely wider, confined to explanate margin, narrowly continuous around apex. Ventral segments 2 to 5 piceous black, 6 to 8 pale, 9 dusky; pygidium piceous black.

Eyes large, separated medially above by less than diameter of eye. Pronotum as in *P. ardens,* broadly rounded in front, lateral margins feebly diverging to hind angles (figure 19); disk finely punctulate, punctures spaced by about four times their diameters, median impressed line obliterated. Epipleurae narrow except at base, attaining middle of abdomen. Ventral segments 6 and 7 large, entirely luminous; segment 8 scarcely emarginate, middle of its apical margin with triangular cusp extending posteriorly and somewhat downward; apex of pygidium narrowly rounded. Aedeagus similar to *P. consimilis.* Length 11.5 mm.

FEMALE. Alate, similar to male, less elongate, elytra relatively shorter. Eyes smaller, separated by more than diameter of eye. Ventral segment 6 pale and luminous in median third or more of width, sometimes more or less pale each side, 7 usually with two small submedian pale spots near apical border, these sometimes lacking.

VARIATIONS. The pronotal vitta may be broadest in front, narrowing slightly toward base, rarely diffusely entering anterior coarsely punctate area. The outline of the pronotum is inconstant and specimens occur with the anterior margin more narrowly rounded medially, or with the lateral margins subparallel, but rarely are they feebly converging at the hind angles. The pale parts of the pronotal disk may be flavate instead of rosy. Ventral segment 8 of the male varies from entirely pale to partly or entirely piceous. In one male example, tentatively associated, the elytra are entirely piceous black. Length 8–12.5 mm.

DISTRIBUTION. VIRGINIA. *Shenandoah Park:* 1 paratype, 1 female, VII–12–52, Dr. Buck (CAS). *Pocosin,* 5 miles north of Swift Run Gap: 22 paratypes, VII–4–47, H. S. Barber (USNM), 2 paratypes, same data (CAS). WEST VIRGINIA. *Brush Creek* mouth: 1 paratype, VII–18–30, J. G. Needham (CU). NORTH CAROLINA. *Mt. Mitchell:* 6711 ft., holotype, 2 paratypes, 1 female, VI–24–37, Hans L. Stecher coll. (CAS). *Sunburst:* 1 male, 1 female, VI–7–39, O. L. Cartwright (CAS). *Cherokee:* 1 paratype, VI–28–88 (CAS). *Montreat:* 2 paratypes, VII–14–28 (CAS). *Black Mountains:* Van Dyke coll., 3 paratypes, 4 females, VII–02 (CAS); 1 paratype, VII–02 (Frost); 1 paratype, VI–02 (CAS); 1 female, VI–24 (AMNH). *Graybeard Mountain:* 1 paratype, 1 female, VI-19 & VI–7 (AMNH). *Cranberry:* 2 paratypes, VI–13, VI–15, H. W. Wenzel (OSU). TENNESSEE. *Johnson City:* 1 female, 2–4000 ft., VI–12–51, O. Bryant (CAS). *Great Smoky*

Mountain National Park: 4 paratypes, 3 females, Chimney Camp, VI–14–47, H. Dietrich (CU); 1 female, Greenbrier Cove, VI–19–42, H. Dybas (CNHM); 1 paratype, Chimney Camp, VI–12–54, H. E. & M. A. Evans (CU).

This species is an Appalachian offshoot of the more northern *P. ardens,* from which it differs in its broader form, generally darker pigmentation, and better defined pronotal vitta, the disk each side clear fulvous or flavate and unobscured by darker maculation.

(28) **Photinus ardens** LeConte

Photinus ardens LeConte, 1851, Acad. Nat. Sci. Philadelphia, Proc., (2), 5:334.
Photinus taedifer LeConte, same as above.
Photinus obscurellus LeConte, same as above, page 335.
Photinus frigidus E. Olivier, 1888, Soc. Ent. France, Ann., (6), 8:54. (new synonymy)

MALE. Form similar to *P. pyralis,* somewhat more elongate. Pronotum with poorly defined median dark vitta attaining base but not apex, about half as wide as convex disk, pale area each side more or less obscured by nubilous brownish or piceous spots, rarely completely obscured; coarsely punctate borders dusky flavate. Scutellum and mesonotal areas dark piceous. Elytra dark brownish piceous, varying to pale brownish gray, sutural bead flavate, usually indistinctly so near scutellum, lateral pale border wider, confined to explanate margin, more broadly continuous around apex. Ventral segments 2 to 5 dark piceous, 6 to 8 pale, 9 dusky, pygidium dark.

Eyes large, separated medially above by less than diameter of eye. Pronotum usually with anterior margin regularly and broadly arcuate, lateral margins subparallel or feebly diverging posteriorly, usually not at all converging at hind angles (figure 19); disk finely and moderately closely punctulate, punctures spaced by two to four times their diameters, median longitudinal line obliterated. Epipleurae narrow except at base, attaining middle of abdomen. Ventral segments 6 and 7 large, entirely luminous, 8 not or very feebly emarginate, middle of its apical margin with short variable cusp, obtuse or acute; pygidium narrowly rounded at apex. Aedeagus similar to *P. consimilis.*

FEMALE. Alate, similar to male, form broader, elytra relatively shorter. Eyes smaller, separated by more than diameter of eye. Ventral segment 6 pale and luminous in median third or more of width, usually pale each side except more or less broadly at basal exterior angles, 7 entirely dark, or variably maculate with nubilously defined pale areas, these usually confined to apical half of segment.

LENGTH. Both sexes, 7–12.5 mm.

DISTRIBUTION. Maine. *Augusta:* VI–24–53, A. H. Brower (Frost). *E. Machias:* VI (CAS). *Paris:* VII–13–49, C. A. Frost (CAS). *Knox County:* VI-20-50 (OSU). New Hampshire. Franconia: (CU). *Colbrook:* VII–21 (AMNH). *Manchester:* (INHS). *Durham:* VI–26 (INHS). *Hampton:* VI–26 (EL.Aug). Massachusetts. *Ayer:* VII–2–24, H. S. Barber (USNM). *Monterey:* VII–19–39, E. A. Chapin (USNM). *Framingham:* VI–21 to VII–18 (Frost). *Sherborn:* VI–22 (Frost). *Natick:* VI–6 (Frost). *Chatham:* VII–14 (Frost). *Berlin:* VI–13 (Frost). *Forest Hills:* VII–4–15, F. X. Williams (CAS). *Worcester:* (CAS). Connecticut. *Cornwall:* VI–8 & 12 (CU). *Storrs:* VI–26–20, J. A. Manter (Frost). New York. *Ithaca:* VI–17 (CU); VII–17, Ringwood (CU). *Paul Smiths:* VI–19–25 (CU & CAS). *Fulton:* VI–20 (CU). *McLean Bogs,* Thomkins County: V–30 & VII–9 (CU). *Buffalo:* VI–25–09 (CAS). *Peterboro:* VI–17–28, G. S. Miller (USNM). Pennsylvania. *Milford:* Pike County, VI–1–41 (Malkin). *Belfast:* V–27–37, J. W. Green (CAS). *Columbia X-roads:* VIII–4 & 27–37, R. M. Leonard (CAS). New Jersey. *Ramsey:* VII–6 (AMNH). Maryland. *Baltimore:* VI–20–09, F. E. Blaisdell (CAS). West Virginia. *Sistersville:* VI–16–30 (CAS). Ohio. *Millersburg:* VI–18–31, R. P. Thomas (CAS). Michigan. *Marquette:* VI–28 (CAS). *Horn Mountain Club:* VI (CAS). *St. Joseph County:* V–30–41, R. R. Dreisbach (CAS). Indiana. *Hessville:* V–27–11, W. J. Gerhard (CNHM). Illinois. *Chicago:* VI–23–09, W. J. Gerhard (CNHM). *Algonquin:* (INHS). Wisconsin. *Bayfield:* Wickham (CAS). Minnesota. *Duluth:* (CAS & SDSC). South Dakota. *Volga:* (SDSC). Newfoundland. "Terre Neuve," Ern. Olivier (USNM). Nova Scotia. *Baddeck:* VII–26–27 (USNM); VI–19–31, G. Fairchild (USNM). Quebec. *Duparquet:* VII–1–41, G. Stace Smith (CAS). *Aylmer:* VI–23–36, G. Stace Smith (CAS). Ontario. *Toronto:* (CAS). *Prince Edward County:* VI–18 (Frost); VI–22 (McClay).

Specimens in the United States National Museum collection, labeled "Terre Neuve," "*Photinus frigidus* Ern. Oliv.," and "Specimen typicum originale auctoris, Ern. Olivier," undoubtedly belong to *P. ardens* and constitute the basis for the synonymy above proposed.

LITERATURE CITED

Castlenau, Francis L.
1833. Essais d'une rev. du genre Lampyre. *Société Entomologique de France, Annales*, vol. 2, pp. 122–153.

Fall, Henry C.
1927. New Lampyridae. *Brooklyn Entomological Society, Bulletin*, vol. 22, pp. 208–211.

Gemminger, M.
1870. Coleopterologische Hefte, vol. 6, pp. 1–131.

Germar, Ernst F.
1824. Insectorum species novae, pp. 1–624.

LACORDAIRE, JEAN F.
1857. Histoire naturelle des insects. Genera des Coleopteres, vol. 4, pp. 1–579.
LECONTE, JOHN L.
1851. Synopsis of the Lampyrides of temperate North America. *Academy of Natural Sciences of Philadelphia*, Proceedings, vol. 5, pp. 331–347.
1878. Coleoptera of Florida. *American Philosophical Society, Proceedings*, vol. 17, pp. 353–472.
1881. Synopsis of the Lampyridae of the United States. *American Entomological Society, Transactions*, vol. 9, pp. 15–72.
LINNÉ, CARL VON
1767. Systema Naturae, edition 12, p. 2.
OLIVIER, ERNEST
1888. Etudes sur les Lampyrides, *Société Entomologique de France, Annales*, vol. 8, pp. 35–62.
SAY, THOMAS
1825. Descriptions of new species of coleopterous insects. *Academy of Natural Sciences of Philadelphia, Journal*, vol. 5, pp. 160–204.
WRAY, DAVID L.
1950. Insects of North Carolina, second supplement. North Carolina Department of Agriculture, pp. 1–59.

PROCEEDINGS
OF THE
CALIFORNIA ACADEMY OF SCIENCES
Fourth Series

Vol. XXVIII, No. 16, pp. 615–621, 1 fig. November 26, 1956

A COLLECTION OF BIRD REMAINS FROM THE PLIOCENE OF SAN DIEGO, CALIFORNIA

BY

LOYE MILLER
Museum of Vertebrate Zoology
University of California, Berkeley

A small collection of fossils from the San Diego Formation (Pliocene) constitutes the subject of this report. The material, collected over a period of some four years, by Mr. Joseph Arndt, was generously presented to me by the collector. With the exception of one bone, of which there were several duplicates, all specimens were placed in the Museum of Paleontology of the University of California at Berkeley. The single exception, a complete humerus of *Mancalla diegense,* was sent to the United States National Museum in Washington.

During my later years of residence in Los Angeles several young men of San Diego, including Mr. Arndt, sent me bird material from the San Diego Formation and I finally recommended to Dr. Hildegarde Howard of the Los Angeles County Museum that her institution take up some serious exploration there. This was done with most satisfactory results. A composite skeleton of *Mancalla* has been assembled and mounted at the Museum, and much additional material representing ten species of birds and a seal is now preserved at the Los Angeles Museum and at the University of California at Los Angeles.

Material

In Mr. Arndt's contribution there are forty-eight items that are recognizable as bird bones. Others are identifiable as ear bones of small cetaceans, limb bones of a small pinniped, rib fragments, and numerous fish remains.

THE DEPOSIT

The San Diego Formation has been discussed in earlier publications (Howard, 1949; Miller and Howard, 1949). It may be stated here in brief that it represents a shallow-water marine accumulation in an enclosed embayment with sand bars at approximately tidal level and small islands that served as breeding grounds for sea birds or cliff dwellers.

ACKNOWLEDGMENTS

My sincere thanks are extended to Mr. Joseph Arndt for donation of the material, to Dr. Herbert Friedmann of the U. S. National Museum for the loan of a partial skeleton of *Phodilus badius,* to Dr. A. Wetmore for his most helpful examination of the type specimen of *Lechusa stirtoni,* and to Dr. Alden H. Miller for suggestions on preparation of the manuscript.

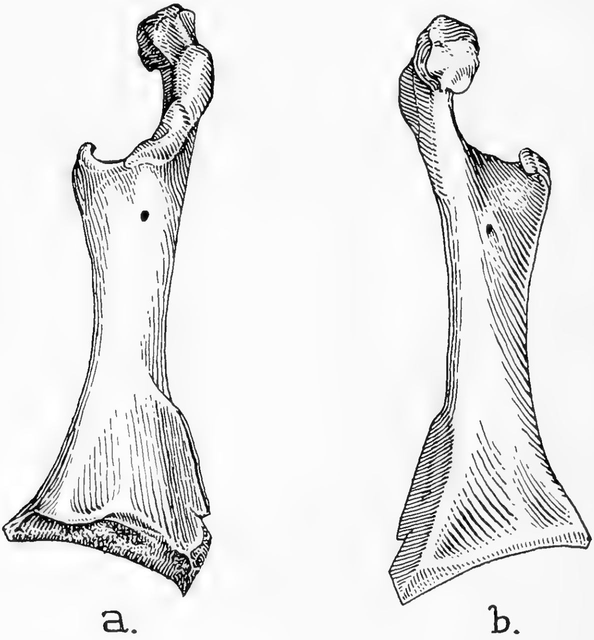


Figure 1. Type specimen of *Lechusa stirtoni.* A – Dorsal aspect. B – Ventral aspect. Approximately x 2. Drawings by Gene Christman.

List of Pliocene Bird Bones in the Arndt Contribution of June, 1955

Gavia concinna Wetmore. A single humerus, lacking only the head. The size is identical with a specimen figured by Brodkorb. The humerus figured by Howard is from a smaller bird that was later described by Brodkorb (1953) as *Gavia howardae.*

Gavia howardae Brodkorb. One tibia, lacking the distal condyles and the cnemial process. The total length must have been very slightly less than in males of *Gavia stellata* but the bone is "stockier," particularly where it widens out distally. The missing condyles must have supported a larger foot than is found in Recent specimens of *G. stellata.* Brodkorb states in his original description of *G. howardae,* based on the humerus, that the species is slightly smaller than *G. pacifica* or *G. stellata.*

Colymbus parvus Shufeldt. One tibiotarsus, proximal two-thirds Howard (1949) speaks of the tibiotarsus of this species taken from the San Diego Formation as "similar to *Colymbus grisegena* or *C. auritus* in physical characters, but between the two in size with closest approach to *C. grisegena.*" Our specimen is assigned with confidence to the species *C. parvus.* A specimen of the distal tibial condyles, very badly water worn, is likewise assigned, but with much less assurance. A complete coracoid only slightly smaller than that of *C. grisegena* seems certainly to be of the species *C. Parvus.*

Colymbus sp. Dr. Howard reported a grebe smaller than *Colymbus parvus* from the San Diego beds and suggests that, were the material more complete, a heretofore unknown species would need to be described. The present collection contains also some imperfect bones of a small grebe. With continued collection from the area we should ultimately come to a fair understanding of this smaller species and a specific category could be designated with confidence.

Puffinus kanakoffi Howard. A single complete humerus represents the Procellariiformes in this collection. The bone is shorter by 3 mm. than that of a male of *P. opisthomelas* (19080 MVZ), but is actually thicker and broader in the shaft and through the distal condyles. The radial condyle is slightly heavier. Certain elusive differences in the head region are difficult to describe though they are apparent during direct comparison.

Phalacrocorax kennelli Howard. The type specimen is a coracoid (incomplete) from the San Diego Formation which "agrees in size with *P. pelagicus*" (Howard, 1949). The ulna is heretofore unknown. In this collection there is a complete ulna almost the exact length of that of *P. pelagicus;* hence it is assigned to the species *P. kennelli.* It is, however, a markedly more slender bone than that possessed by *P. pelagicus,* with smaller articulations both proximal and distal. The internal cotyla is narrower than it is in either *P. pelagicus* or *P. penicillatus.* Likewise the external cotyla has a less pronounced hook on its distal extension than is found in either of the Recent species. The head of a right humerus is also assigned to this species though it is very slightly narrower than in *P. pelagicus.*

Brachyramphus (?) **pliocenus** Howard. This species, described by Howard (1949), was based upon a humerus lacking the distal end. Referred material included a complete ulna, the distal ends of two humeri, an incomplete cranium, and the articular end of a lower mandible.

We now have a perfect tarsometatarsus that comes from a bird of about the same size and familial relationship. Since there is no association of parts in the matrix of these beds, the first impulse would be to assign all of these parts to the same species. The tarsus, however, does not resemble that of *Brachyramphus* so much as it does others of the auklets. It is shorter and stouter than in *Synthliboramphus antiquus,* more slender than in *Ptychoramphus aleuticus,* and very closely resembles that of *Aethia pusilla* though very slightly stouter. I shall look forward to the recovery of further material that may give greater assurance to the generic assignment of *B. pliocenus.*

The tarsus (No. 45662, UC Mus. Paleo.) in question shows the following characters: length very slightly greater than in *Aethia pusilla* but stouter with broader head and foot; hypotarsus almost identical with that of *Aethia* and quite different from that of *Brachyramphus;* anterior face of head and shaft more as in *Brachyramphus* than in *Aethia,* however, in its being more excavated. The tarsus of *Aethia* is almost flat. The fossil is very similar to *Ptychoramphus.* It is much more slender although but slightly shorter. Its head is very similar, as is the hypotarsus also (4 ridges instead of 3). The excavation of the shaft is the same, but the inner condyle is set off a bit more gradually and is more distinct from the middle condyle and thus is strongly suggestive of *Sterna,* though the bone is that of an alcid.

I suggest reassignment of the species to *Ptychoramphus* or to a new genus.

Mancalla californiensis Lucas and **Mancalla diegense** (L. Miller). I am continually astonished by the abundance of *Mancalla* remains that come from the San Diego Formation. There are 48 bones in the present shipment from Mr. Arndt that are recognizably avian. Of these 34 are assignable to the genus *Mancalla.* At the time of our joint publication (1949), Dr. Howard and I were fairly confident that two species of the genus were present, at least during part of the year, in Pliocene San Diego though the larger *M. californiensis* was in the decided minority. With the accumulation of more material through the intervening years, that confidence has reached the point of practical certainty. In this latest accession there are fragments of humeri that even exceed in size Lucas' type from Los Angeles. No humerus of the larger form, however, is complete though three from the smaller form, *M. diegense,* are almost as perfect as recently prepared bones. One coracoid seems almost beyond question to have come from an immature individual.

Lechusa stirtoni, new genus and species. Stirton's Owl. Type specimen No. 45331 University of California Museum of Paleontology, a right coracoid from Lower–Middle Pliocene (San Diego Formation) San Diego, California, collected by Joseph F. Arndt. This specimen, a single almost perfect coracoid, represents a heretofore unknown genus and species of Barn Owl (Family Tytonidae). Size approximately equal to the corresponding bone in the male of *Tyto alba pratincola,* the living Barn Owl. Though shorter it is relatively heavier through the shaft. Head slightly larger and less globular (i.e., more angular). The triosseal canal is slightly larger. The procoracoid process is placed lower on the shaft and its axial border merges more gradually into the shaft below the fenestra. The shaft is relatively broader at the central zone. In all but one of eight Barn Owls examined, there is a tendency to form a notch on the axial border just above the sternal articulation. During life of the bird this represents a fenestra in the tough membrane that seals off the anterior end of the thoracic cavity. The one exception shows some evidence of juvenility. The fossil coracoid lacks this frail character and the margin is less sharp-edged in that region.

The proximal end of the coracoid is about equal in width to the average in Recent Barn Owls but the inter-muscular line on the ventral surface, instead of being almost rectilinear, is strongly curved outward as its proximal end.

Unfortunately the sterno-coracoidal margin is not entirely preserved, but the suggestion is that the pectoralis-tertius muscle is less strongly developed, with respect to the pectoralis segundus, than it is in the Recent specimens of *Tyto.*

Furthermore this intermuscular line is depressed almost to disappearance at a region between 5 and 6 mm. distal to its external extremity. The whole bone is depressed in this area in a manner difficult to define with accuracy yet it is evident to the eye. There is herein a resemblance to the Short-eared Owl, *Asio flammeus.*

When the bone is viewed from the proximal end, the sternal facet appears weaker than in *Tyto* and its dorsal margin falls away as the eye travels toward the external margin of the bone.

The dorsal aspect of the bone offers another one of those intangible yet observable differences. It suggests that the sterno-coracoidal process (unfortunately incomplete) began more abruptly to diverge from the shaft and it began at a point farther up the shaft, i.e., toward the coracoidal head.

The missing portion of the process may have been more extensive than at first suspected. In which case the pectoralis tertius muscle may not have been reduced as is suggested by the out-swing of the intermuscular line on the ventral surface of the bone. In other words this muscle may have been attached more to an expanded process and less to the shaft of the bone.

We thus appear to have a Pliocene owl that is definitely related to but differs from the Recent Barn Owls, a strongly marked group of almost world-wide distribution with but limited geographic modification.

The fossil was submitted to Dr. A. Wetmore of the Smithsonian Institution who very generously gave his reaction from which, by permission, I quote the following: ". . . it proves to belong in the Barn Owl family Tytonidae but represents what I consider to be a peculiar and unknown genus. . . . The lower end of the intermuscular line on the ventral (external) surface, however, shows a tendency toward what is found in typical owls. . . . A very interesting new genus and species of barn owl that shows some cross over toward the other family of owls." I greatly appreciate Dr. Wetmore's friendly courtesy and find myself in full accord. I feel sure, however, that neither of us would place too great emphasis on the suggestion of "cross over" as a phylogenetic indicator particularly in the absence of a complete sterno-coracoidal process.

Although the Pliocene bird so strongly resembles the living forms of *Tyto,* it was not considered permissible to establish a new category within the family Tytonidae without examining the only other living genus assigned to that group, *Phodilus badius* of the Indian orient. This peculiar creature has been bandied about somewhat freely by three or four generations of systematists but has finally come to rest (it is hoped) in a monotypic sub-family of Tytonidae, the Phodilinae (Peters, 1940). After much delay and correspondence, the body skeleton of this species was obtained on loan from the U. S. National Museum. The most casual inspection of this material was sufficient to show that the Pliocene bird is not assignable to that sub-family. This is not the place to discuss the relationships of the genus *Phodilus* further than to say that its assignment to a distinct sub-family, if not even a full family, appears to be well founded.

The true Barn Owls are set off so positively from all the other Strigiformes that this Pliocene form seems to occupy a position of considerable importance. Certainly it is one of great interest.

The taxonomist who searches through the literature on the nocturnal birds of prey finds much confusion down through the years, in the application of generic and specific names. *Strix, Asio, Otus, Syrnium, Scops,* and *Athene* have all been pretty freely shuffled about or even reversed as generic and specific terms.

It seemed proper to this writer therefore to introduce a new strain into the "taxonomic blood stream." In northern Mexico and Arizona the name *lechusa* (Latin-American spelling) is applied to the Barn Owl in distinction from the eared owls that are called *tecolote*. I have therefore chosen a generic name from the Spanish instead of the Greek. The specific name is proposed in honor of my long known friend and colleague in Paleontology, Dr. R. A. Stirton.

SUMMARY

Additional information is presented regarding several Pliocene species of water birds. Generic re-assignment of one species is suggested. A new genus and species of Barn Owl is described.

LITERATURE CITED

BRODKORB, P.
1953. A review of the Pliocene Loons. *Condor*, vol. 55, pp. 211–214

HOWARD, H.
1949. New avian records from the Pliocene of California. *Carnegie Institution of Washington Publication* 584, pp. 177–199, pls. 1–3.

MILLER, L., and H. HOWARD
1949. The flightless Pliocene bird *Mancalla*. *Carnegie Institution of Washington Publication* 584, pp. 201–228.

PETERS, J. L.
1940. Birds of the world, vol. IV. Harvard University Press.

INDEX TO VOLUME XXVIII

FOURTH SERIES

New names in **bold-face** type

ERRATA

Page 19. Line 13 from bottom: for Calytraeidae read Calyptraeidae.
Page 21. Line 4 from bottom: for *Calytraea* read *Calyptraea.*
Page 63. Line 20 from top: for Callapidinae read Callaphidinae.
Page 77. Line 2 from top: for *Methiola* read *Mathiola.*
Page 84. Line 10 from bottom: for *Mandevillea* read *Mandevilla.*
Page 96. Line 6 from bottom: for *paraguariensis* read *paraguayensis.*
Page 107. Line 5 from top: for *Matiola* read *Mathiola.*
Page 122. Line 7 from bottom: for *Taraxicum* read *Taraxacum.*
Page 141. Line 6 from bottom: for *alstroemeria* read *alstroemeriae.*
Page 141. Line 14 from top: for *graviolens* read *graveolens.*
Page 146. Line 5 from top: for *arietnum* read *arietinum.*
Page 146. Line 28 from top: for *Eyphorbia* read *Euphorbia,* and for Speng. read Spreng.
Page 147. Line 3 from bottom: for *Mandevillea* read *Mandevilla.*
Page 150. Line 12 from bottom: for *guajara* read *guajava.*
Page 359. Line 9 from top: delete Leptodactylidae.
Page 442. Line 2 from top: for *sauteri* read *sauterii.*
Page 463. Line 20 from top: for *Ukanodes* read *Unkanodes.*
Page 469. Line 7 from bottom: insert "Fennah, new species" after **Dicranotropis huensis.**
Page 535. Line 5 from top: for C.A.S. 26318 read C.A.S. 26314. [In the original description of *Hynobius ikishimae* Dunn (Proc. Calif. Acad. Sci., 1923, ser. 4, vol. 12, no. 2, p. 28) the number of the holotype specimen is given as C.A.S. 26318. However, in his revision of the salamanders of the Family Hynobiidae (Proc. Amer. Acad. Arts and Sci., vol. 58, no. 13, p. 493, June, 1923) Dunn lists C.A.S. 26314 as the type specimen. C.A.S. 26314 is noted in the Department's catalogues as the holotype, and this, which had been segregated from an extensive series of this species, bears a special "type tag." It is evident that a typographical error was made in the printing of the original description, and this error was unwittingly perpetuated by Slevin and Leviton.—A. Leviton.]
Page 535. Line 15 from top: for *vanderburghii* read *vandenburghii.*
Page 535. Line 27 from top: for *Plethedon* read *Plethodon.*
Page 538. Line 7 from top: for June 15, 1934, read June 13, 1934.
Page 538. Lines 22 and 29 from top: for J. P. Heath read H. Heath.
Page 538. Line 32 from top: for (orig. no. 6240) read (orig. no. SU 6240).
Page 543. Line 15 from top: for C.A.S. 49599 read C.A.S. 49498, and for J. Health read H. Heath.
Page 558. Error of omission: add *27a*—1931. Log of the Schooner "Academy." *Occasional Papers of the California Academy of Sciences,* vol. 17, 162 pp., 16 pls., February 14.
Page 560. Error of omission: add 7a—1913. The correct status of *Elaps collaris* Schlegel. *Notes from the Leyden Museum,* vol. 35, pp. 171–175.